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LECTURES

ON

ANATOMY:

INTERSPERSED WITH PRACTICAL REMARKS.

VOL. III.

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&c. &c. &c.

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INTRODUCTION.

In pursuance of the general plan of my Lectures, this Volume will be found to contain that portion of the anatomy of the human body, which is more particularly connected with physiology.

Some apology may be necessary for the extent to which I have entered upon physiological subjects in a work professedly anatomical; but as my object is to embody a complete system of anatomy, in connection with physiology and surgery, I have considered it my duty to pay more particular attention to the many important discoveries which have of late years been made, and are still in progress; in order that the student may be so far interested, as to lead him to seek the fullest information, in the numerous works now before the public, on the valuable and interesting science of physiology.

London; October, 1831.

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LECTURE XXII.

GENERAL ANATOMY OF THE MUCOUS MEMBRANES.

In the first and second volumes of my Lectures on Anatomy, I have treated of the bones, ligaments, muscles, and those structures which form the exterior of the human body; I shall now proceed with the anatomy of the internal cavities, and their contents.

The *mucous membranes* form an interior lining to all the cavities and glandular structures, which either directly or indirectly have a communication with the atmospheric air. The consideration of these membranes, therefore, seems properly to follow that of the external integuments; not only on account of their actual continuation or prolongation from them, but from their being alike destined to protect the parts which they cover from the injuries of external agents.

From these circumstances the mucous membranes have been termed the internal tegumentary system, and, as we shall hereafter have occasion to observe, they possess many characters in common with the external integuments. Indeed, in an anatomical point of view, a close alliance has been admitted, ever since the time of Galen. Meckel classes them as the external and internal cutaneous systems; Beclard terms them both tegumentary membranes; while Blainville speaks of them under the general appellation of envelope or covering: from whence we may learn, that however they are classed, the characters which they present in common, form a very prominent feature.

These membranes are the organs of some of the most important functions of life, and equally in a physiological

and pathological point of view, an accurate knowledge of them is of the greatest moment to the medical, as well as the anatomical student. It is on the mucous membranes that external agents first act; in them resides that undiscovered vital power which effects the great chemical changes that are exerted in the processes of digestion, absorption, and excretion; and to them also are applied our therapeutical agents.

The term mucous membrane, was taken originally from the viscid secretion of the schneiderian membrane of the nose; but it is now extended to the various linings of the digestive, pulmonary, urinary, and genital organs, together with those glandular structures which have excretory ducts communicating with them. To these are also added the tunicæ conjunctivæ, and excretories of the lacrymal glands, the membranes lining the cavities leading from the mouth and fauces to the ear, and sinuses of the bones of the skull.

Bishat has classed the mucous membranes in two great divisions or surfaces,—the gastro-pulmonary, and the genito-urinary,

The *gastro-pulmonary*—commences with the tunicæ conjunctivæ, at their point of contact with the external integuments on the edges of the eyelids; two processes extend from each tunica conjunctiva,—one along the duct of the lacrymal gland, the other through the puncta lacrymalia, the lacrymal sac and duct, to its junction with the schneiderian membrane of the nose; it then lines the nasal cavities communicating with the external skin at the anterior openings of the nostrils; while upwards it sends portions which are continued into the sinuses within the bones of the cranium, and backwards it is continued into the fauces, pharynx and mouth; from the mouth processes are sent to the parotid, submaxillary and sublingual ducts; from the pharynx prolongations extend from the eustachian tubes to the cavities of the tympana and mastoid cells; while in the back and lower part of the pharynx it divides into two principal portions, the anterior of which passes through the

larynx, trachæa and bronchia, to their ultimate distributions; while the posterior passes down the œsophagus to the stomach and remaining portion of the alimentary canal, terminating at its junction with the external integuments at the anus. In the alimentary canal it gives off two processes, the one to the ductus communis choledochus, proceeding from thence to the ductus hepaticus, ductus cysticus and gall bladder; the other to the ductus pancreaticus. This completes the gastro-pulmonary division.

The *genito-urinary* division—commences at the orifice of the urethra, continues along it to the bladder, giving off processes in its passage to Cowper's gland, the prostate gland, vesiculæ seminales, vasa deferentia, and their ramifications within the testes. From the bladder two processes proceed along the ureters to the pelves, infundibula, mammillary processes, and probably to the uriniferous tubes of the kidneys.

In the female, this division of the mucous membrane continues, as in the male, to the bladder and urinary organs, but necessarily offers many differences in the genital organs, in which it lines, first, the vulva, then the vagina, uterus, fallopean tubes, and at their fimbriated extremities are supposed to open into the serous cavity of the broad ligaments.

In the female there is a distinct mucous membrane, which belongs to the mammæ, extending from the nipples along the lactiferous tubes to their ultimate division.

In the examination of the mucous membranes and their secretions, we shall find that they present a variety every where commensurate with the function of the organ with which they are connected; and so great is this variety, that one function cannot be considered, in the remotest degree, to depend upon their actual continuity with each other, or with the common integuments.

The appearance of the mucous secretions, as well as their qualities, are widely different in the different organs, even although they are continuous and situated near to each other; as, for instance, the secretion of the schneiderian membrane

and the tunicæ conjunctivæ; and again, between the secretion of either of these membranes and that which is found in the tympanum, mastoid cells and sinuses, where it is rather of an oily than a mucous nature; these latter cavities in a healthy state are filled with air, and mucous secretion is not traceable beyond the canal of the eustachian tube, either in man, or other animals possessing such structures. From this fact, as well as from the appearance of the interior of these cavities, there is reason to doubt whether or not mucous membrane does enter them; particularly as such a secretion would probably interfere with the sense of hearing. It may further be remarked, that in certain species of the reptile tribe the tunicæ conjunctivæ are detached from the gastro-pulmonary mucous surface; and in certain fishes, the membrane lining the nasal organs is also detached.

Those writers who insist upon the identity of the mucous membranes with the common integuments, have endeavoured to support their theories, by adducing certain analogies which are found to exist between the inferior orders of animals and the embryo state of the human fœtus. These analogies are traced in the changes which are asserted to take place in the progress of the growth of the fœtus, and are compared with a similar, though permanent, existence in different animals. There is, however, a very wide difference between analogies and real identity; and mere analogy not unfrequently proves a source of delusion, obscuring the simplicity of truth, which can alone be established on the firm basis of demonstrable fact. The circumstances here alluded to, and particularly dwelt upon by Blainville, are however extremely interesting; inasmuch as they shew the extensive power resident in membranous structures: the reader must, however, follow his own judgment in admitting the deductions of the above-named ingenious author. He commences with instances of the general envelope of living bodies in their simplest form; as in the zoophite, where one external surface, in contact with the

fluid in which the animal exists, appears to serve all the purposes of nutrition, respiration, and generation. Proceeding in the scale of animal perfection, the polypus presents not only an external surface, but an inverted or internal cavity, having but one orifice leading into it; this orifice serves the double purpose of mouth and anus, and, as may be seen through the medium of a good solar microscope, both the food and the young animals are ejected by one and the same effort of contraction. In the next stage of perfection, we observe this internal cavity furnished with two openings, the intermediate space being more or less lengthened into the form of a canal,—the continuity with the external surface still remaining unbroken. As we ascend the scale, we find the same internal cavity performing separate and distinct functions, being divided into numerous portions, each appropriated to separate offices. Thus the respiration becomes a distinct function from generation, and digestion is performed by organs separate from either one of them: at the same time, the membranes which compose these external and internal surfaces become more complicated in their structure, not only in certain distinct layers of which they are composed, but in the number of follicular, papillary, and glandular formations superadded to them.

The above scale of existence is compared with the human embryo, which, during its earliest state, is supposed to consist entirely of skin and mucous membrane. The anterior part of the body and the intestinal canal are at this period open, and form a perfect continuity. The skin afterwards closes, the junction being made apparent in the existence of the mesian line of the body; at the same time the walls of the intestines unite to complete the alimentary canal: at this period, also, the mucous membranes are thinner, and more simple in their structure. Towards the sixth month, the valvulæ conniventes and convolutions make their first appearance in the intestines; while the sebaceous glands are abundantly developed in the common integuments. The surface of the fœtal body is now defended by an oily

secretion, which protects it from the liquor amnii, otherwise perhaps destructive to the cuticle, which is destined for the future contact of the atmospheric air. In the intestines, also, a mucous secretion of a viscid quality is formed; at first it is of a whitish color, but afterwards it is changed to a dark green, as is seen in those discharges from the rectum after birth, known by the name of the meconium.

It seems most probable, that these substances are in the first instance a secretion from the sebaceous follicles, and in the latter from the mucous membranes of the alimentary canal.

The analogies between the mucous and integumentary systems are, however, supported by the circumstances, that they both present one free and one attached surface; in other words, they are both distributed on the surfaces of other structures, forming together one unbroken connection. Their free surfaces are uneven, and furnished with superadded structures, in which they differ from the serous membranes. The most remarkable fact denoting the similarity which exists between them, is in the reciprocal convertibility of their surfaces in particular situations. Thus, when a part of the mucous membrane becomes constantly exposed to the drying effects of the atmospheric air, as occurs in certain cases of artificial anus, or of prolapsus uteri and ani, it will gradually acquire the properties of external integument, and will be covered by a cuticle and rete mucosum; on the other hand, when a part usually covered with external integument is defended from the effects of the air, in consequence of continued pressure, and is at the same time in a state of moisture from the perspiration of the part, as in certain cases of permanent contractions of joints, &c., such parts will acquire the properties of mucous surfaces. There is therefore, undoubtedly, a close alliance between these membranes; but nothing in that alliance to establish their identity. The nervous system, in its various distribution, presents a much closer alliance; but who has ever endeavoured to prove that the eye is derived, by continuity, from

the ear; or the sense of taste in the mouth, from the sense of touch in the skin? On the contrary, do not all these structures, so various in their properties and functions, prove that they are endowed exactly with those qualities, and no others, which are alone subservient to the functions they are each destined to perform?

Physical Properties and Anatomical Structure of the Mucous Membranes.

The mucous membranes are composed of a dense cellular tissue, having two surfaces,—one free, and the other attached to the organs with which they are respectively connected. Their tissue is not areolated, as in the common integuments, but is more fibrous; and in certain instances, as in the petuitary membrane, it is of a spongy or fungous structure. The ancients described the basis of the mucous membrane as an expansion of a nervous nature, giving it the name of *tunica nervea.* This substance in situation answers to the cutis vera, and in certain instances, as along the œsophagus, is furnished with a cuticular covering; while in others a viscid mucous secretion appears to be a mean of protection against the injuries of external agents. The free surface of the mucous membranes is composed of innumerable villi and papillæ, interspersed with follicular and glandular appendages, hereafter to be described, and which are more or less abundant in different situations. These appendages have received various names; such as the villous, fungous, porous, villoso-papillary, and the petuitary membranes.

The color of the mucous membranes varies from a pale yellow to a deep red or brown, and frequently they are of a mottled appearance; depending partly on the quantity of blood circulating, and partly on the coloring matter natural to them. Their density is less than that of the common integuments, but is greater than that of the cellular tissue.

Their extensibility and flexibility is considerable, more particularly in the hollow viscera, the stomach, intestines, and urinary bladder. In these, however, great power of

extension is to be attributed to the unfolding of the rugæ which exist in the collapsed state of those viscera.

Their contractibility or tone is very great, and exceeds that of the common integuments. In certain situations, as in the mouth, this power is exerted with great rapidity; while in others, as in the uterus after parturition, it is slower and more gradual.

Their irritability is a matter of controversy; and although admitted by some anatomists, it is doubtful whether or not this power resides in the mucous membranes themselves, independent of the subjacent muscular structures. Stimulants have been variously applied to them in the living animal, without evincing any power of contraction.

Their sensibility is exquisite, particularly in the nose, tongue, tunica conjunctiva, glans penis, urethra and vagina; for the most part, however, there is an obscure sensibility not readily perceived by the mind. To this sensibility we must refer the sense of hunger, thirst, repletion, &c.; the sensations caused by the retention of the urine and fæces; and no doubt all the phenomena attendant on the progress of parturition, and which generally commence when the uterus has attained a certain degree of distention. Excepting in the situations above named, there does not appear to be an abundant supply of nerves distributed to the mucous membranes; which is more remarkable, on account of the high degree of vital activity possessed by them. This feeble state of sensation is particularly apparent in the œsophagus, through which fluids of a high temperature will pass, and be lodged in the stomach without producing an uneasy sensation; while other fluids may be possessed of such acrid qualities, that their presence in the mouth, or even upon the common integuments, would be attended with most sensible pain. Excepting the particular senses, the nerves distributed to the mucous membranes are derived principally from the great sympathetic and pneumo gastric nerves; at all the natural openings of the intestinal canal, the nerves proceed from the brain and spinal marrow.

The mucous membranes, in certain situations, are abundantly supplied with blood-vessels and lymphatics, subdivided into the most minute ramifications, and for the most part constituting a capillary system of circulation. All the mucous membranes are by no means similarly circumstanced in this respect; and there is likewise a remarkable difference in the quantity of blood which the same membrane receives at different times, as, for instance, in cases of asphyxia and syncope, when they become loaded.

Haller, and some other physiologists, have asserted, that the whole mucous system is furnished with an epidermis; these assertions appear to have no other support, than the presence of certain layers of lymph which form during an inflamed state, and which have been mistaken for cuticular separations. The epidermis may be traced along the œsophagus, as far as its junction with the stomach, It is again very apparent in the vagina, but is lost at the orifice of the uterus; it is found at the orifices of the intestinal canal, from whence it becomes gradually imperceptible.

Of the Appendages or Parts superadded to the Mucous Structures.

These consist of villi, follicles, papillæ, and mucous glands. Blainville has classed the superadded parts of the whole tegumentary system under two heads. The first, comprising all the modifications of follicles or crypts, from the Greek word κρυπτω, to *hide* or *conceal*; the second, phanere, from the word φανερος, *evident* or *manifest*. We have here to speak of the follicles or crypts, so abundantly supplied to the mucous membranes. They are situated within the substance of the membranes, having open mouths upon their surfaces. They are composed of an external fibrous covering, having two openings,—one internal, for the passage of vessels and nerves, which are necessary for its function; the other sometimes produced in the form of a canal, for the exit of the produce of its secretion. Within this fibrous tunic, adherent

to its internal surface, is a second tunic, of a very vascular construction. This is filled with a fluid which, after being retained for a certain period, appears to obtain a more viscid or inspissated consistence, and is ejected by the external orifice to perform its particular uses. These uses are various; in the stomach and intestines it is of a solvent quality, resembling a chemical action, and is subservient to the process of digestion: in the mouth it is of a solvent and various quality; in the nose viscid, forming a protection to the sentient nerves of smell; it is also spread over surfaces to protect them by mucous or greasy secretions: upon the whole, however, these secretions are of a mucous nature. In the intestines the animal differs from the vegetable mucus, in possessing a larger proportion of azote. When in a liquid and pure state, mucus is of a transparent white color; in this state specimens have been obtained from the gall bladder when the ductus cysticus has been long obstructed; the mucus so collected is as transparent as rock crystal; and although possessing a considerable degree of fluidity, it has such a degree of tenacity, that it may be drawn out in threads like melted glass. Although this is the state of mucus under the above circumstances, and it may be considered as a pretty uniform production of the animal system; yet its appearance varies, from numerous sources of admixture in the different membranes. In the bladder and urinary passages, in their healthy state, only such a quantity appears to be secreted as is necessary to defend them from the acrimony of their proper secretions, and in them its presence is rarely perceptible, excepting in a state of disease. From the compound nature of the mucous membranes, and their complicated secreting appendages, it is by no means easy to determine how much of the quantity and quality of their secretions is to be attributed to the membranes themselves, and how much to their appendages. In the mouth, fauces and intestines, and particularly at the os tincæ, it is evident that mucus is the product of the follicular apparatus; yet the presence of a quantity of

mucus in situations not abundantly supplied with follicles, leave no room to doubt that the membranes, as well as their follicles, are capable of producing it.

Anatomical investigation has not yet enabled us to point out a variety of structure corresponding to these various powers resident in the mucous membranes. It is obvious, that considerable variety must be met with in the analysis of mucus, from various situations; Berzelius gives the following analysis of mucus, taken from the nose and bronchia:—

Water	933 ·9
Mucous matter	53 ·3
Hydrochlorate of potash and soda	5 ·6
Lactate (acetate) of soda and animal matter	3 ·0
Soda	0 ·9
Phosphate of soda, albumen, and animal matter	3 ·3
	1000 ·0

It is soluble in water, and in dilute sulphuric acid; it is not coagulable by heat, nor precipitated by corrosive sublimate; as an animal compound, it forms one of the immediate principles of organization.

The general classification by Blainville of the appendages of the integumentary membranes into crypts and phanere, and the structure of the former above alluded to, is too superficial when compared with the varieties presented in the villi, papillæ, and glandular follicles attached to the mucous membranes. Of these we shall now give a more particular description.

The villi, compared to the pile of velvet, are very generally distributed on the inner or free surface of the mucous membranes; they are extremely small, being only about one-fourth of a line in length, and usually require the aid

of a lens to be seen distinctly. Their size varies in different situations: they are larger and thicker on the upper portion of the small intestines, than on the lower part; less in the stomach; less in the large intestines and bladder; and are scarcely, if at all perceptible, in the sinuses of the head. Meckel has enumerated about four thousand of them upon one square inch of intestine. According to Beclard, their form is that of laminæ, or leaves, variously disposed in the stomach, jejunum, colon, &c.; while by other anatomists they have been described as conical, cylindrical and tube-like. From injections it is apparent that they have an abundant circulation of blood-vessels. The veins are also numerous, and have an erectile disposition. The absorbents, according to Cruickshank, are numerous, and terminate in open mouths; from fifteen to twenty of which he counted on a single villus of the jejunum.

Other anatomists assert, that the villi consist of a spongy gelatinous substance, which is the seat of absorption; and deny that the chyliferous vessels have open mouths; whence it may be concluded, that the subject is still involved in obscurity. Nerves have not been traced to the villi, although there can be but little doubt that they possess them abundantly.

The next kind of appendage we shall notice, is the papillæ, so named from their resemblance to small nipples. These are more distinct than the villi, particularly on the dorsum of the tongue, where they may be seen with the naked eye. Four classes have been enumerated, distinguished by their various forms: they are the filiform, the conical, the fungiform, and the lenticular or truncated. They have also been distinguished by their various sizes into papillæ majores, mediæ, and minimæ. They are formed of a delicate cellular tissue, on the surface of which is distributed an abundant circulating medium. Nervous filaments have been traced to them in the tongue, nostrils and glans penis.

The follicles or mucous glands, are the next species of appendage, and which particularly characterise these mem-

branes; their minute anatomy, as given by Blainville, we have already alluded to; but there are other circumstances regarding them worthy of notice. Excepting the opening mentioned by Blainville for the passage of nerves and vessels, these membranes are in the form of a *cul de sac*, varying in shape, number and size, in different situations. They are round or oval, infundibular or lenticular. They are most numerous in the palate, bronchia, œsophagus, and intestinal canal. They have obtained various names: the smallest have been termed the cryptæ minimæ, and are pretty equally dispersed; in the duodenum they are larger, and are placed in an isolated order,—hence termed glandulæ solitariæ; while in the ileum they are formed in clusters, termed the glandulæ aggregatæ. When several are united, they have the appearance of proper glands: in which class certain anatomists place the tonsils, glands of Cowper, and even the prostate. Those follicles which have large mouths, are known by the name of lacunæ, as in the urethra and rectum, &c.

La Vagna, Walter, Bonn and Blainville, have classed the teeth among the appendages of the mucous membranes; their obvious bony structure, and characters, do not bear sufficient analogy to these membranes to induce me to describe them separate from other bony structures.

Pathological View of the Mucous Membranes.

The mucous membranes are the seats of a great variety of diseases, which bear a certain resemblance to each other in their general character; although varied according to the different situations and functions of individual parts. Of these diseases the greater number fall more immediately under the care of the physician than of the surgeon; the knowledge of them is however of great importance, on account of the extensive variety of morbid appearances connected with them, and which the surgeon is constantly called upon to characterize and describe in *post mortem* examinations: for which reason, I shall give a more lengthened detail of

the diseases incident to mucous membranes, than otherwise would be consistent with a work on anatomy.

The mucous membranes are constantly liable to inflammation, from various causes. Their general appearance, in an inflamed state, is that of a deeply reddened surface, in consequence of the infinite multitude of minute vessels suffused with blood. This surface, so reddened, will be spotted with minute points of a still deeper color, so uniform as to resemble small patches in which ecchymosis has taken place. In this state, the inflammation may exist in the mucous membrane itself, without extending to the subjacent tissues; but when intense, and of long continuance, the mucous membranes will become thickened, their secretions altered, and a variety of appearances will arise, among which the following are most prominent:—the membrane will become softer in its texture, so as easily to be torn by the pressure of the finger; the surface will become irregular, assuming a granular appearance, not unlike a healing ulcer. These appearances are often seen on the tunica conjunctiva, during the progress of purulent opthalmia, and in the alimentary canal, more frequently in the larger intestines in cases of severe dysentery; they may also be seen in cases of bronchitis. Such appearances occasionally assume an inordinate elevation, when they have been termed caruncles or granulæ, as on the inner surface of the eyelids, and in the colon. When inflammation has proceeded to these morbid productions in the mucous membranes, their secretions have generally become puriform; at first, their secretion may either be entirely stopped, or abundantly increased in quantity and fluidity, being much less viscid than usual; or it may be more firm, and not so readily dissolved in other fluids. The abundant watery secretion which often accompanies it will become charged with salts, and will be extremely irritating and acrimonious; from this state the secretion may assume its natural character, as it gradually returns to health; but, on the contrary, the secretion may change to a puriform consistence, which continuing, will terminate in

an ulcerated process. To ascertain the nature of a secretion of pus, or mucus, observations have been made with an instrument called an Eriometer. It consists of two slips of glass; a drop of fluid is placed between them, which will be found on pressing the pieces of glass, to refract light in different degrees, according to the consistence or structure of the fluid submitted. Thus true pus is ascertained by the globules which it contains refracting light in concentric rings; while mucus, being destitute of globules, will not present these appearances.

Ulcerations of a character peculiar to the mucous membranes, commence in numerous points, producing small vesicles; these have a close relation to aphtha. This vesicular form of ulceration has been supposed to depend on the presence of an epidermoidal covering, its progress having been observed in all its stages only in the mouth, where the epidermis is to be traced. Sometimes the edges of ulcerations will be much thickened, irregular, and of a bright florid color, particularly when in the intestines; in this state the subjacent structures appear to participate in the disease. Another form of ulceration peculiar to the mucous membranes appears in numerous spots, and seldom occupies any extent of surface; the edges of these ulcerations are not elevated or thickened, or accompanied by an evident increase of vascularity or alteration of color: ulcerations of this description are met with in the trachæa and alimentary canal. Ulcerations will also arise from the deranged state into which these membranes will be thrown, in consequence of the complete suppression of their secretions; instances of which are met with in the nose, fauces, and particularly in the small intestines. The mucous membranes are particularly liable to chronic inflammations, perhaps more so than any other structure in the human body. In such cases, the mucus is either thicker or more viscid, or it assumes a purulent consistence: of such a nature are those discharges called gleety, and blennorhœal. The membranes are uneven or granular, thickened, and often more dense than in acute

inflammation. Their tenacity is, however, less than in health, and they are not easily detached from their subjacent parts, being readily lacerated. Their vascularity, in some instances, is much increased; but in others, the parts affected will be unusually pale, or of a brown, grey, or black color. The latter color, may however arise from the presence of carbonaceous matter, and may not indicate a chronic affection.

Great difference of opinion has arisen respecting the reproduction of mucous membrane, in situations where it has been partially destroyed. Like the common integuments, the mucous membranes may maintain an ulcerative process, which shall only destroy their exterior surface, and which will be completely restored in the process of reparation; but if the ulcer produces a total destruction of the whole thickness of the membrane, a cicatrix is the consequence, in the mucous membranes as in the common integuments. Such restored surfaces bear but a mutilated character, and the mucus yielded from them is as dissimilar from natural mucus, as an external cicatrix is from perfect skin. As in the external integuments mucous membranes are restored by granulations proceeding from the edges of the healing ulcers; so also, as in the skin, the new cicatrices of the mucous membranes exhibit a strong tendency to contract; this is seen in the production of strictures in the urethra, and rectum; this power of contraction is also occasionally seen in the fauces, after deep and extensive ulcerations.

The various mucous membranes are the seats of certain specific diseases, or poisonous affections; thus the urethra, and tunica conjunctiva, are particularly liable to the infection of gonnorrhœa; the nose and throat, to syphilis; scarlatina affects the throat, as well as the common integuments; measles will affect the upper part, or even the whole course of the bronchial tubes; hydrophobia the larynx, the pharynx, and the stomach; arsenic the stomach, and rectum; and cantharides, the bladder.

Gangrene affects the mucous membranes, in consequence of a very high degree of inflammation; as is seen in the

intestines, and more frequently in the throat: in other instances, it occurs from deficiency of nutrition, as in certain cases of colica, where the muscular coats are subject to violent action. In cases of strangulated hernia, introsusception, removal of a prolapsed uterus, or of a polypus by ligature, the mucous membrane dies with the subjacent parts, and undergoes the usual processes of ulcerative separation.

The mucous membranes are subject to a change in their tenacity, and become completely softened. This occurs generally in the gastro-intestinal mucous membrane, and more particularly in that portion of it lining the stomach. Various causes have been assigned as the origin of this morbid state; it is not improbably closely allied to those cases of gangrene, already alluded to as being produced from a defect of nutrition, and is by many considered to arise from a chronic inflammation of the sub-mucous cellular tissue, which occasions a defective circulation in the mucous membranes themselves.

Some few cases have been recorded of ossification in the mucous membranes; these are rare, and have been met with only in the uterus, and in the gall bladder. Their conversion into cartilage, has also been recorded to have taken place in the œsophagus, and in the lungs; in the latter situation, however, the cases mentioned by Beclard appear rather to depend on those morbid changes connected with tubercles, than on the changes in the mucous membranes themselves.

In common with most other structures of the body, the mucous membranes are liable to fungus hæmatodes. This disease arises much more frequently in the sub-mucous cellular tissue, than in the mucous membranes themselves; when in the latter, it assumes the form of cysts, hanging in clusters from short peduncles. In some instances, several pedunculated bodies are attached to one common peduncle, in others from a larger cyst partly enclosing them: these occur in the urinary bladder, and in the trachæa. In other instances, this disease assumes the form of warty fungus of

the skin. It has been supposed, that from the nature of the cavities in which these malignant diseases occur, their growth is more rapid, not being impeded by pressure, as in structures of greater solidity.

In diseases, particularly of the lungs, the liver, and the heart, the mucous membranes are often found in a state of congestion; in which the veins are more particularly filled with blood, presenting a cadaverous hue, which has often been mistaken for inflammation. It is not improbable, that this state is frequently produced by the last efforts of expiring life, which are unable to carry on the current of blood beyond the arterial influence. The mode of death, as well as the particular situation in which these appearances are found;—the congestion being most abundant in the veins, and being more equally diffused than in inflammation; the membrane being neither indurated nor softened, and the secretion on its surface being little, if at all altered from a natural state;—form the best criteria to guide our judgment in these cases.

Bichat has recommended the dissection of living animals, in order to gain a correct knowledge of the appearances of the mucous membranes, before and after death.

The follicles are frequently the seat of disease; they may either be simply enlarged, or, retaining their contents, form tumours; such cases are met with occasionally in the labial glands. The mucous membrane surrounding a follicle will frequently take on inflammation, in consequence of irritation commencing in the follicle itself; in this state they either swell, forming an elevation, or they present an areola of increased vascularity, which terminates in an ulcerative process; more particularly apparent when the follicles are situated in clusters. Not unfrequently malignant ulcers arise in these structures, as in the lips, the anus, and the os uteri.

Emphysema occurs in the sub-mucous cellular tissue, and has been met with under the mucous membrane of the stomach, intestines, and biliary ducts.

Œdema also frequently occurs in the sub-mucous cellular tissue, and when in the epiglottis and chordæ vocales, often proves fatal. Œdema is sometimes occasioned by disease of the heart, of the liver, and by chronic peritonitis.

Inflammation of the sub-mucous cellular tissue may exist, accompanying that of the membrane itself; and instances are mentioned by Andral, in his paper on chronic gastritis, of its continuance in this structure after it has subsided in the mucous membrane.

The sub-mucous cellular membrane is sometimes filled with an infiltration of pus; this has been met with in the air passages, and in the alimentary canal, and occasionally in small isolated patches in the small intestines.

In other instances, an effusion of a more plastic character occurs, which gives rise to contractions, as in the hour-glass contraction of the stomach, contractions of the canal, of the œsophagus, urethra, and intestines.

The sub-mucous cellular tissue is also the seat of fatty tumours, membranous cysts containing hair, teeth, and fat, and those tumours of minute vessels termed erectile tissue; of this latter character, are certain forms of hemorrhoids. This tissue is also liable to all the forms of disease which have been termed malignant, which often make considerable progress before the mucous membranes themselves become affected. As these diseases advance, the membranes become remarkably softened, give way, and ulcerate; presenting, however, a somewhat different character from that which commences in the membrane itself. As connected with the mucous membranes, it may here also be proper to mention, that the muscular structure beneath them, partakes of disease in consequence of their derangement; and will be remarkably thickened, as is seen in the bladder, pylorus, stomach, and urethra, in consequence of strictures, or the progress of malignant diseases.

GENERAL ANATOMY OF THE SEROUS MEMBRANES.

In continuation of this subject, the serous membranes next claim our attention. These structures, like the mucous membranes, are distributed upon the surfaces of those organs with which they are connected: and, like them, present one attached, and another free secreting surface; but, unlike the mucous membranes, they form closed sacs, having no communication with the atmospheric air.

These membranes form a very extensive secreting surface, and are termed serous, in consequence of the numerous vessels they contain, and from the peculiar fluid with which they are always found to be moistened bearing great resemblance to the serum of the blood.

They are found in different situations in the body, and may be divided into those which line the interior of cavities, giving a covering to the viscera within them; into those which form synovial sacs, and which are connected with the articulations and tendons; and into such as are placed immediately under the skin. With but one exception, all the serous membranes form closed sacs or bags, without presenting an opening into any other structure; so that their secretion is entirely isolated. The exception to this arrangement is found in the instance of the fallopian tube opening into the peritoneal cavity in the female.

The form of the serous bags differ very materially in different parts of the body; sometimes presenting small rounded sacs, at others, running for a considerable distance along tendons, and dividing into numerous processes in blind pouches; and again, as is seen in the splanchnic serous membranes, they so closely cover certain viscera as

more or less to resemble in figure the organ to which they are attached; or they may form so many prolongations between the different viscera, as to render it impossible to describe their peculiar configuration: but it is to be remembered, that, as all the viscera which are covered by these membranes are external to their secreting cavities, the membrane is always reflected from one viscus to another as a double membrane, and that the connecting and intervening processes must necessarily maintain their internal cavities.

The serous membranes not being of the same structure as the organs which they connect and enclose, form one of the best distinguishing marks of separation of one organ from another.

There are certain differences in the character of the two surfaces of all the serous membranes. An *external* one which is rough, or rather cellular, and is connected with more or less firmness either to ligaments, tendons, cartilages, or some of the viscera contained within the cavities of the body. The *internal* one, termed the free surface of the membrane, is smooth, polished, and moist; but, however, if examined through a microscope, it may be said to present somewhat the appearance of villosities, but which appearance seems rather to depend upon the whole membrane being thrown into folds, than upon any doubling of its internal surface.

The splanchnic serous membranes sometimes form such reflections as to produce two sacs, one within the other, as may be observed in the reflected portion of the peritoneum, termed the omentum.

The organization of the serous membranes very much resembles that of the cellular tissue, presenting a homogeneous surface in their texture, without any appearance of fibres; and are only to be distinguished from the cellular membrane by their being more of a condensed nature, by forming distinct cavities, and being somewhat transparent and brilliant. Some of the serous membranes are so similar to the cellular tissue, as scarcely to be distinguished.

The blood-vessels of the serous membranes are not easily discerned, unless the membrane be held up to the light, when their opacity admits of their being observed; they circulate only the colorless parts of the blood, and are termed by some anatomists the exhalents: these vessels will, however, under inflammation, circulate red blood, when the redness of the surface of the membrane proves the abundance of its vessels. Numerous absorbents also enter into the composition of these membranes. Nerves have not yet been traced to them.

Among the physical properties of these tissues may be remarked their extensibility and contractility, which is proved by the size they acquire in dropsy, and the power they have of resuming their natural size upon the removal of the extending cause: but the whole of this extension is not to be attributed to the texture of the membrane only, but in part to the unfolding of its duplications from the pressure of the fluid.

The splanchnic membranes possess this extensibility to a greater degree than the synovial capsules.

The function of the serous membranes is to secrete and reciprocally absorb their natural fluids, always maintaining a certain quantity within their cavities for the purpose of lubricating their internal surfaces, and diminishing, therefore, the friction of the parts upon each other; if, however, from any cause, such as an increased arterial action producing too abundant a secretion, or the absorbents have their activity diminished, then the cavity so affected becomes distended with fluid, and dropsy of the membrane is produced.

The office of facilitating the motion of the organs which are covered by these membranes, is not the only use attributed to them; they are by some physiologists considered as essentially important in improving the assimilation which arises from the deposition and absorption of their secreted fluid. The fluid secreted by these membranes is not of the same appearance and quality in all of them: that produced

from the splanchnic is supposed by most physiologists to be exhaled in a gaseous form, and becomes afterwards condensed by cold; but Magendie believes, that during life a small quantity is always to be found in a fluid state. It has much the same appearance as serum, offers nearly the same result from chemical analysis, is like it,—being in the greater part coagulable by heat, but leaves an incoagulable portion resembling in every respect the serosity of the blood.

The synovial capsules secrete a peculiar fluid, possessing very different qualities; the most remarkable of which is, its resemblance to the white of an egg, from which it has derived its name; and from its containing a small proportion of fibrin.

During the fœtal period of life, the serous membranes are found very thin, and generally less adherent to the surrounding parts, than in after periods. In more advanced epochs of life, they undergo changes as to numbers, as may be seen in the separation of the cavities of the tunicæ vaginales from the peritoneum.

The *sub-cutaneous serous membranes*—or superficial bursæ mucosæ, are found under the skin, in parts subjected to great motion and liable to pressure against bone. Such a membrane may, therefore, be invariably found between the skin and ligamentum patellæ; and which is frequently the subject of disease, from the continued pressure of kneeling. The texture of these sacs is the same as other serous membranes; but in their thickness they sometimes vary, between that of synovial and the splanchnic serous membranes, and, in a like manner, secrete a fluid within their closed cavities, for the purpose of facilitating the motion of the surrounding parts. Their developement and morbid changes are similar to the rest of the serous system.

The *synovial membranes*—which are classed with the serous, have been described when treating of the joints. (*Vide Vol. I. page* 179.)

The *internal serous* or *splanchnic membranes*—are those of which it is now my office more particularly to treat.

These membranes not only give more or less of a general covering to the viscera contained within the cavities of the body, but also are reflected from them, so as to give a covering to the parietes of the cavities themselves. They are found in different parts of the body, and are distinguished by particular names.

The peritoneum covers the organs of digestion, urinary organs, and those of generation; and serves an essential office in maintaining these parts in their relative situation, and diminishing the effects of friction, resulting from their motion upon each other.

The thoracic splanchnic membranes are three: two pleuræ, which surround the lungs and the parietes of the chest, and the pericardium, which is in the same manner reflected around the heart.

The arachnoid membrane is of this system, and forms the serous covering of the brain; while the tunicæ vaginales, in a like manner form coverings to the testes

Of all these the peritoneum is the largest, but as regards their composition, function, organization, and physical properties they resemble each other; they all line the internal surface of the cavities, and cover the viscera, which are contained within them; establishing at the same time a medinm of connection, as well as a line of demarcation between the different organs, and serve in particular to facilitate their motion. The internal surface of these membranes is furnished with villosities, which become very apparent under inflammation, but when healthy it gives a shining appearance both to the viscera and the cavities themselves: an appearance evidently belonging to the serous membranes, for if it be stripped off, all the glistening disappears.

The peritoneum is the most complicated of all the serous membranes in its conformation; from having such various and numerous viscera to cover, and so large a cavity to line, that we shall find some difficulty in tracing it as a continuous

membrane, throughout all its intricate foldings and attachments.

Although it has been said that the splanchnic serous membranes are connected with the viscera and parietes of the cavities, still it is to be observed that they are not adhering with the same firmness throughout every part of their extent. The degree of solidity of the adhesion is greatest while the membrane is attached to the organs, or to a continued surface of the parietes; but at the point where it is passing from the one to the other it is found much less firmly adherent, and thrown as it were into folds, so that the hollow viscera may become distended by the unravelling of these folds, and resume their form when the cause of distention is removed.

Such folds facilitate the enlargement of an inguinal hernia, the peritonial sac being formed of a duplicature; while on the contrary, an umbilical hernia, which is covered by a portion of peritoneum that lines and is firmly attached to the umbilicus, yields with greater difficulty, and is sometimes either torn through, or absorbed, in consequence of the pressure. This circumstance has given rise to the opinion of some surgeons, that umbilical herniæ are not furnished with a peritoneal covering.

In a state of health the splanchnic serous membranes secrete but a small portion of fluid which is capable of coagulation by heat, and is said by Dr. Bostock to contain—

Water	92	0
Albumen	5	5
Mucus	2	0
Muriate of soda . . .	0	5
In a	100	0

When these membranes are dried they lose their semitransparency and become yellow, their flexibility is diminished and they become elastic; moisture, however, restores their physical properties, but continued maceration dissolves them, shewing that they are composed of gelatine.

Pathology of the Serous Membranes.

The splanchnic serous membranes are very liable to inflammation, but not all of them equally so, as the pleuræ and peritoneum, and even the pericardium we find much more frequently affected than the tunica arachnoidea, or the tunicæ vaginales. When inflamed, however, they have a tendency to be alike affected with dropsy, formation of false membranes, adhesions, and accidental productions.

On examination of a dead body, adhesions of the pleuræ are very frequently found: and even where there had been no symptoms during life to lead to the suspicion of such alteration in structure: these adhesions are formed by a secretion from the membranes during a state of inflammation, and resemble the organizable matter which produces reunion of the edges of membranes when wounded.

A continued chronic inflammation of the serous membranes alters their structure; they become thicker, lose their transparency, and are liable to a morbid secretion within their cavities, sometimes of serum only, and at others of a milky fluid, and lastly of pus.

The false membranes that are found seem to be produced by becoming organized by the vessels of the inflamed membranes, and bearing the general characters of the cellular tissue, remain permanently as adventitious.

The splanchnic serous membranes are also liable to many accidental productions, as fibrous, cartilaginous, or osseous: these changes do not unfrequently occur on the pleura, but the peritoneum, and more particularly, it has been said, that portion of the peritoneum covering the spleen, is the subject of osseous deposit. These portions of bone are usually deposited in thin plates upon the membrane.

The serous membranes are very liable to be transformed into a cellular tissue; nor, as Andral has observed, need it create much surprize when we find in health these tissues frequently performing functions for each other. Thus, when a synovial bursa is found in one individual, in another there is

only found cellular tissue, lubricated with a fluid more abundant and unctious than the usual secretion of that tissue. Meckel gives several reasons for believing in the natural affinity between the serous and mucous tissues, among which are the following:—First, that their exterior aspect is similar; and if the cellular tissue be inflated, small cells are produced, which are not to be distinguished from the finer serous textures. Such cells are seen in the omentum, and the tunica arachnoides, &c. Secondly, that like cellular structures, nerves have not been traced to them. Thirdly, that the functions of each are the same; namely, exhalation and absorption: and there are other arguments in favour of this hypothesis. One grand anatomical difference separates these two systems: namely, that the serous membranes form close sacs, while all mucous membranes open upon the surface. We shall presently see a decided distinction in the results of morbid action. The various cysts which are so frequently found in the body are similar to the serous membranes, presenting closed pouches, and an internal secreting surface, which pours out a lubricating fluid. Such cysts are found at the extremities of the stump of amputated limbs, in cases of unreduced dislocations, and non-united fractures. Mr. Brodie mentions having found a large serous cavity between the skin and the protuberance of a distorted spine. From these facts we may infer that the cellular membrane, under the necessity for altered function, may undergo a change in structure, rendering it capable of performing its new office, as we see pressure and motion will convert it into a synovial cyst; and in the same manner, the false or adventitious membranes, resulting from inflamed serous bags, will become transformed into a cellular tissue so as to enable them to perform the office of the common connecting medium. These newly-formed cysts are liable to various transformations, being convertible into the fibrous, cartilaginous, or osseous tissues; and their secretions are also found to be extremely variable, indeed, from the natural serous lubricating fluid, to all the varieties of pus, and even malignant formations. But

the principal desideratum for the surgeon, connected with the pathology of the serous membranes, and more especially of the splanchnic, is, their tendency to the adhesive inflammation.

This peculiar result of inflammation, whether acute or chronic, forms the grand pathological feature connected with this class of membranes. The constant attempt of nature to repair injuries, and guard against the fatal effects which would occur in many such instances, is here most beautifully exemplified. When a wound of any serous cavity takes place, unless the accidental lesion be instantly fatal, or certainly irremediable (in which latter case, no restorative means are even attempted by nature), the first effort is to set up an adhesive inflammation. Some of the loose floating viscera come in contact with the external wound of the parietes, and a close adhesion between them takes place,—shutting up the opening into the general cavity; nay, more, if the wound pierce not only the parietes, but even a viscus,—as, for instance, a small intestine,—the wounded portion of the gut comes in contact with the exterior wound, and prevents the almost certainly fatal results of effusion of the intestinal contents into the serous cavity of the abdomen. Again, in severe diseases of articular surfaces, this form of inflammation sometimes steps in, and supersedes the last sad resource of the surgeon, amputation, by producing adhesion of the surfaces, and obliterating the joint. This form of inflammation, when perfect, consolidates the part, and produces anchylosis.

I have not yet spoken of the similarity between the living membrane of arteries and the serous tissues, because the analogy is not complete; but I may be permitted to state, that in external characters its smoothness and polish, its want of red blood-vessels and nerves in the healthy state, its elasticity and general aspect, lead me to infer a close relation between them; while the effects of injury to the inner coat of an artery is well known to the practical surgeon as productive of an inflammation, similar to that of

serous textures. It forms our best safeguard in many of the higher operations of surgery; as ligatures on these structures well exemplify.

Simple inflammation produces other results in serous membranes, as merely thickening, for example in the white spots on the serous covering of the heart; and tubercular granulations, as in the affection of the peritoneum, described by Barron: also false membranes, dense bands, and various adventitious productions, frequently found in the larger serous cavities. Many of these accidental productions of the serous membranes are resolvable into distinct cellular tissue; as we have frequently had occasion to witness in old adhesions of the lungs to the ribs; and internal bands within the abdomen, which not unfrequently give rise to fatal strangulations of the intestines. Many bony concretions found within closed sacs, are probably dependant on morbid conditions of the serous textures; as the loose concretions in synovial capsules, and tunicæ vaginales. May we not also refer to a similar source, various serous cysts, which are generally but erroneously called hydatids; especially the kind known by the name of acephalous cysts.

These matters are, however, more the province of the morbid anatomist to enquire into, and would not here be introduced were it not for the surgical deductions which may be usefully inferred from such observations.

The structure, physiological and pathological considerations of the peritoneum being duly appreciated by the student, he will find it better next to study the relative position of the organs contained within the cavity of the abdomen, before he traces all the attachments of the peritoneum; to do which he would necessarily be obliged to displace the viscera, and thus preclude the possibility of learning their precise relative boundaries. But as a necessary preliminary to this investigation, it is advisable to gain a correct knowledge of the anatomical divisions of the external parietes of the abdomen.

LECTURE XXIII.

OF THE ABDOMEN AND ITS CONTENTS.

The abdomen is that part of the body situated between the chest and the lower openings of the pelvis; it presents a figure of an oval form, being more or less convex anteriorly; but its figure and dimensions vary at the different epochs of life, as well as from the degree of distention of the viscera proper to it.

The comparatively larger size of the abdomen in the infant, its apparent flatness and contraction at the adult period, as well as its greater vertical dimensions in the female, are subjects rather for the consideration of the physiologist than the anatomist, and I shall therefore refer my readers to physiological authors. It is right to observe, however, that the capacity of the abdomen is greater than that of either the skull or chest, and its size less determined, in consequence of its parietes being made up principally of soft parts; while that of the scull is completely formed by the bones of the cranium, and the capacity of the chest limited to the motions of the ribs and sternum: hence it is that effusion into the abdomen is not attended with the same danger, as when it occurs in the cranium or chest. The capacity of the abdominal cavity seems to be in proportion to the necessity for food, and the kind of food taken; thus it is found that the abdomen in the infant is comparatively large when a great quantity of nutrition is required; and becomes much less capacious in old age, when the activity of digestion is diminished, although its external parietes are at that period enlarged from the accumulated deposition of adeps.

The abdominal cavity is bounded, *above,* by the diaphragm and the ribs to which that muscle is attached; *below,* by the ossa innominata, and the muscles which fill up the pelvic openings; *behind,* by the lumbar vertebræ, and muscles of the loins; *laterally,* by the false ribs, ossa ilia and abdominal muscles and their tendons.

There are some anatomists and physiologists who condemn the term, cavity of the abdomen, because the parietes are always in contact with their contents; but as it is the term in common use, I cannot see any just reason for adopting any other name for the space which contains the abdominal viscera.

The abdomen is divided into an *external* and *internal* surface.

The external surface is covered by the skin, and is not only divided into an anterior, two lateral, and a posterior region; but, for physiological as well as surgical and medical purposes, to enable us in description more accurately to speak of the relative position of its contents, it has been found necessary to subdivide the abdomen into several arbitrary regions.

With this object in view, the abdomen has been divided first, into three regions, described by drawing two lines transversely across its surface,—the upper extending between the extremities of the cartilages of the ninth ribs, and the lower one between the anterior and superior spinous processes of the ilia.

The upper region, situated above the line drawn from one rib to the other, between it, the sternum, and the ribs, is termed the *epigastric* region. The middle compartment between the two lines is called the *umbilical* region. While the lower, which is bounded above by the line drawn from one ilium to the other, and below by the os pubes and the ligaments of Poupart, is termed the *hypogastric* region. But these divisions are each further subdivided into three regions by drawing a vertical line on either side from the junction of the cartilage of the ninth rib with the eighth, to the spinous processes of the pubes.

The epigastric region thus divided in its middle compartment, immediately under the ensiform cartilage, is termed the *scrobiculus cordis;* while its lateral regions, from being situated under the false ribs, are termed the right and left *hypochondriac* regions. The middle region in its centre retains the name of *umbilical;* but laterally, is called the right and left *lumbar* region. The inferior division or *hypogastrium,* in the centre gains the name of *pubic* region; while its lateral surfaces are called its *iliac* regions.

Such divisions over a continuous surface may appear, at first sight, not only arbitrary, but useless; but, upon bearing in mind the numerous viscera which are contained within the cavity of the abdomen, performing such different functions; and then learning the different positions of these viscera in relation to the nine regions which have been described,—it at once appears obvious, that a just diagnosis in the diseases of the abdominal viscera must be infinitely facilitated, and the surgeon gain great practical knowledge in the treatment of penetrating wounds, and in the various operations connected with abdominal surgery.

It may not be unadvisable for the student in this period of his study of the abdomen, to re-consider what he had learnt during his dissection of the abdominal muscles:—such as the direction of the fibres of these muscles, which so cross each other, as not only to adapt them, in the best possible manner, to sustain the viscera contained within the abdomen; but also, at the same time, to prevent their protrusion; and further, that the arrangement of their muscular and tendinous fibres render them capable, during their contraction, of acting with equal force through every part of the abdomen. The situation of the umbilicus and of the rings, each diminishing the power of resistance of the abdominal parietes at the parts where they are placed, are also subjects worthy at this time of the consideration of the pupil.

The next step is to remove the abdominal muscles; and it would be well if this dissection were performed in a manner

which is not usually recommended, but which, although difficult in execution, would, when performed, thoroughly repay the student for his labour, by giving to him a just view of the fasciæ which actually form the true parietes to the abdominal cavity. Dissecting away the transversalis muscle of the abdomen completely from its attachments, will expose the fascia transversalis lying upon the peritoneum. This membrane may now be traced to its connection with the anterior layer of the fascia lumborum above, and laterally with the fascia iliaca below, so as completely to inclose the viscera and peritoneum in a fascial bag, excepting at the roof of the abdomen, where it is bounded by the concavity of the diaphragm, in the form of a cupola. A portion of the fascia transversalis should now be most carefully raised from the peritoneum around the umbilicus, for the extent of three inches above and below the navel, and two inches on either side; by which there will be exposed four cords,—one running upwards from the umbilicus, and three taking their course towards it from the hypogastric region. These cords, from lying upon the external surface of the peritoneum, have been improperly termed the ligaments of the peritoneum; but they are, in fact, the remains of the umbilical cord. The upper one, the now obliterated umbilical vein, which had, during the fœtal period of life, conveyed the blood from the mother to the embryo; while the two lateral cords below are the impervious remains of the umbilical or hypogastric arteries, which had in utero conveyed the blood back again from the fœtus to the placenta of the mother. The middle cord below is termed the urachus, which passes from the fundus of the bladder to the umbilicus; it is described by anatomists, at every period of life to be an impervious cord, and the use assigned to it in the human subject is, to prevent the displacement of the bladder. In the lower animals it is found to be a hollow tube, conveying the urine which may be formed in the fœtal bladder to the alantoid membrane. It is yet a matter of doubt in my mind, whether or not it be pervious

in the human fœtus; and from a case which I have lately seen, where there were malformations of the urinary and generative organs in a female child, and a discharge of urine from the umbilicus, I am inclined to believe the urachus remained as a hollow tube communicating with the bladder.

The peritoneum should now be laid open to expose its internal, as well as its external surface; which may be done by making an incision through it from the ensiform cartilage to the umbilicus, and from thence, on either side, to the spine of the ilium; and then turning down the inferior flap of the peritoneum which has thus been made, the umbilical arteries are seen projecting on the inner surface of the peritoneum, and forming it into two distinct pouches, on either side, an external and internal hypogastric pouch, or *cul de sac*. The external is the larger and deeper of the two, and is placed in the right iliac fossa, on the outer side of the umbilical artery, in a direction towards the internal ring and crural arch; so that it may in some instances lead to the occurrence of inguinal and femoral herniæ. The smaller and inner *cul de sac*, is placed between the bladder and obliterated umbilical artery, and leads therefore immediately downwards, behind the united tendons of the internal oblique and transversalis muscles, towards the external ring: it is therefore liable to be protruded in direct or ventro-inguinal herniæ.

The structure and the physiological considerations of the peritoneum being duly appreciated by the student, he will find it better next to examine the relative position of the organs contained within the cavity of the abdomen, before he traces the various attachments of the peritoneum; to prosecute which, he would necessarily be obliged to displace the viscera, and thus preclude the possibility of learning their precise relative situations and boundaries.

The viscera contained within the cavity of the abdomen, are divided into three classes: the organs of digestion, with their assistants the chilopoietic viscera; the organs for the

secretion and excretion of urine; and parts of the organs of generation.

But both collectively and individually these viscera, it is to be remembered, are placed without and behind the closed sac formed by the peritoneum; which, in fact, is to be considered as a cavity within a cavity, lining the parietes of the abdomen, and giving more or less of a partial or general covering to the separate organs.

On laying open the cavity of the abdomen, by making an incision through the parietes from the ensiform cartilage to the pubes, and a second transverse incision from the extremity of the last rib on the one side to the other, the following organs present themselves to view:—

The acute edge of the liver, particularly of the right lobe, with the fundus of the gall bladder. In some subjects much more of this organ is exposed in this view than in others, depending upon age, sex, and previous state of health.

The stomach; with a small portion of the duodenum, the greater and less omentum, and such a portion of the small intestines as are not covered by the great omentum. The quantity of small intestines exposed, varies in proportion to the extent of the great omentum, which, in some subjects, reaches much lower than in others.

Such are the parts which are brought into view without any displacement of the viscera. Having named the contents of the abdomen, and those organs which present themselves to view on laying open the cavity, I shall proceed to describe the boundaries of each organ in particular, and their relative position with respect to each other, commencing with the organs of digestion.

The *stomach*—the principal organ of digestion, is a musculo-membranous bag, of an irregular conoid form, lengthened from left to right and from above to below, being placed between the œsophagus and the duodenum; it is situated in the epigastrium, principally occupying the left hypochondriac region; crosses the scrobiculus cordis, and

terminates, at the junction of this region with the right hypochondriac, in the duodenum. It is bounded above by the liver and diaphragm, below, by the transverse arch of the colon and the great omentum; before, by the ensiform cartilage and cartilages of the last false ribs, behind, by the pancreas; on the left, by the spleen, and on the right, by the duodenum. The direction of the stomach is oblique from above to below, and from left to right; and its superior portion, which we shall find forms its lesser curvature, extends from the left of the tenth to the right of the twelfth dorsal vertebra.

At the termination of the stomach to the right of the twelfth dorsal vertebra, the intestinal canal commences; and, taking a very tortuous course through the various regions of the abdomen, terminates at the anus. The length of this canal at the adult period of life, is from six to seven times the length of the body; in the fœtus it is even longer; and comparative anatomy teaches us, that the intestinal canal is longest in vegetable feeders, shortest in carniverous, and intermediate in the omniverous class.

The *intestinal canal* is divided into small and large intestines: the small commence at the pyloric or right extremity of the stomach, and terminate in the large intestines, at the right iliac fossa; the large intestines commence at the termination of the small in the right iliac fossa, take a circuitous course within the cavity of the abdomen, and terminate at the anus.

The *small intestines* are subdivided into duodenum, jejunum, and ileum; which, being bounded in front by the great omentum and transverse arch of the colon, these parts must be turned upwards on the chest to examine their relative position; remembering, however, that the first two inches of the duodenum will be still concealed by the omentum.

The *duodenum*—the commencement of the intestinal canal, is so called from being in length equal to the breadth of twelve fingers; it extends from the termination of the

stomach, on the right of the twelfth dorsal vertebra, to the second lumbar where it terminates on the jejunum. Passing from its commencement to its termination, it takes a tortuous course. For the purpose of facilitating its description, it is divided into three portions; a superior transverse, a middle vertical, and an inferior transverse portion. The superior transverse portion of the duodenum, takes its course from the stomach upwards, backwards, and to the right, as far as the neck of the gall bladder; being in its whole length in the right hypochondriac region. From thence the vertical portion descends into the right lumbar region, resting on the anterior surface of the right kidney and vena cava inferior. The inferior transverse portion passes inwards, and slightly upwards to the left, crosses the second lumbar vertebra, the aorta, and right renal vessels, to terminate in the jejunum. The duodenum in taking this course, describes a semicircle; the convexity of which is directed outwards and to the right; while the concavity, which embraces the head of the pancreas, is directed inwards and to the left. The duodenum is not in all its length equally covered by peritoneum, as its middle or vertical portion is only anteriorly covered by the upper lamina of the transverse mesocolon. Its upper portion is often found tinged with bile, but which probably is occasioned by the transudation of that fluid after death.

The duodenum is bounded *above*, by the liver and gall bladder; *below*, by the inferior lamina of the mesocolon: *anteriorly*, by the anterior layer of the mesocolon, the ascending and transverse arch of the colon; *posteriorly*, by the right kidney, the vertebral column, aorta, vena cava, and right pillar of the diaphragm: on its inner side, by the pancreas; and on its outer, by the muscular parietes of the right lumbar and hypochondriac regions.

The remaining portion of the small intestines, is subdivided into jejunum and ileum; they extend from the left of the second lumbar vertebra to the right iliac fossa, forming numerous convolutions in their course, which pass from above to below and from left to right, occupying the

umbilical and hypogastric regions. They present convexities anteriorly, concavities posteriorly, and are held in their situation by that portion of peritoneum which is termed the mesentery. Although this portion of the intestinal canal is by anatomists subdivided into jejunum and ileum, still the division is perfectly arbitrary, there being no distinction between them in their structure; but the upper two-fifths, which occupy the umbilical region, is called jejunum; and the lower three-fifths, situated within the iliac regions, is named the ileum. These two portions of the small intestines are bounded *above,* by the transverse arch of the colon; *below,* by the bladder and rectum: *before,* by the omentum; *behind,* by the mesentery, cæcum, and the ascending and descending colon.

The termination of the ileum in the cæcum,—with which it forms a right angle,—should be here attentively noticed; after which, the course of the large intestines may be traced.

The large intestines form about one-fifth of the whole length of the intestinal canal; they commence in the right iliac fossa, and terminate at the anus; they take a circuitous course, and are subdivided into *cæcum* or *caput colli, colon,* and *rectum.*

The *cæcum,* or caput colli, is that portion of the large intestines situated in the right iliac fossa, below the termination of the ileum. It is somewhat conical in its form,—the base being situated above, and its apex below. From its under and inner surface a lengthened process, termed the processus vermiformis, extends over the brim of the pelvis and iliac vessels into the cavity of the pelvis. The processus vermiformis is between two and three inches in length, about the size of a quill, and opens from the cæcum, below the termination of the ileum. The use of this organ is unknown; but in the fœtus its dimensions are relatively larger than in the adult. The structure of this process varies remarkably in different animals; in many, it is wholly wanting; in others, it is of a large size, or more than one in number. The cæcum is held in its situation by a por-

tion of peritoneum, which usually only covers its anterior surface, but does sometimes so surround this intestine as to form a perfect meso-cæcum. The cæcum is bounded *above*, by the ascending colon and right kidney; *below*, by Poupart's ligaments; in front, by the abdominal muscles, and sometimes by convolutions of the ileum; behind, by the psoas magnus and iliacus muscles; and on the inner side, by the termination of the ileum, which passes into it in a manner which will be described when treating of the structure and organization of the intestinal canal.

The *colon* commences in the right iliac fossa, above the entrance of the ileum, and terminates at the left sacro-iliac symphisis in the rectum; to reach this point it passes first, upwards, then across the abdomen to gain the left hypochondriac region; then descends into the left iliac fossa, where it forms a peculiar turn which terminates in the rectum. This disposition of the colon, has led to its division into four distinct portions; the *ascending, transverse arch, descending* and *sigmoid flexion:* each of which requires a separate description.

The *ascending colon* extends from the right iliac fossa, through the right lumbar to the right hypochondriac region; it is bounded *above*, by the right lobe of the liver, which it marks with a depression; *below*, by the cæcum, and termination of the ileum: *anteriorly*, it is covered by the small intestines; *posteriorly*, it rests upon the quadratus lumborum muscle, the right kidney and duodenum; *internally*, it is connected with the inferior lamina of the transverse meso-colon, and right layer of the mesentery; and *externally*, it is bounded by the abdominal parietes. Its size does not much exceed that of the small intestines; but there are, even at first view, sufficiently distinguishing marks, which will be hereafter described. It is not very firmly tied down in its course, being connected with the quadratus lumborum muscle and kidney by a considerable quantity of loose cellular membrane.

The *transverse portion*, or *arch of the colon*, extends

from the right hypochondriac region, across the lower part of the scrobiculus cordis, into the left hypochondriac region; in its course forming a convexity looking downwards, and a concavity upwards. Such are the regions which anatomists usually describe the transverse arch of the colon to occupy; but the extreme convexity of the arch, I think, is generally found extending into the umbilical region. This portion of the colon is bounded *above*, by the stomach; *below* and *behind*, by the small intestines; and in *front*, by three layers of the great omentum: the right commencement of the arch is bounded above, by the right lobe of the liver; while its termination in the left hypochondriac region is in contact with the spleen: its concavity is directed upwards and backwards towards the spine, with which it is connected by peritoneum; and its convexity is turned downwards and forwards, toward the anterior abdominal parietes.

The *descending*, or *left portion of the colon*, extends from the left hypochondriac into the upper part of the left iliac region. It is bounded *above*, by the spleen; *below*, by the sigmoid flexion of the colon: *anteriorly*, by the large left extremity of the stomach when that organ is empty, and by the small intestines; *behind*, it lies upon the kidney, the quadratus lumborum, and iliacus muscles, to which it is connected by loose cellular membrane: the peritoneal covering to this part of the intestine, as in the right side, is connected only with its anterior and lateral surfaces.

The remaining portion of the colon, which, from the course it takes to the junction of the last lumbar vertebra with the sacrum, is called the *sigmoid flexion*, or *left iliac colon*—and describes a double curve in the form of the letter S. It is bounded *above*, by the descending colon; *below*, by Poupart's ligament: *before*, by the small intestines, spermatic vessels, and left ureter; and *behind*, it rests upon the psoas magnus, and iliacus muscles. The sigmoid flexion is very loosely connected with the iliac fossa, frequently descending into the pelvis. When a portion of this intestine, or, on the right side of the cæcum, become pro-

truded from the abdominal cavity, they are not usually closed in a peritoneal sac.

The last portion of the intestinal canal is the *rectum*—which begins where the sigmoid flexion of the colon ends, opposite the left sacro-iliac articulation, and extends to the anus. The commencement of this intestine is directed slightly from left to right, and from above to below, taking the curved form of the sacrum, until it reaches the junction of the sacrum with the os coccygis, when it takes a direct course towards the perineum. The rectum is firmly fixed in its situation by the peritoneum, which does not however give it an equal covering throughout its whole extent; its upper third is surrounded by this membrane forming in this situation the meso-rectum; the middle third has only an anterior covering from the peritoneum, which is reflected from the bladder in the male subject, and from the vagina in the female; while the lower or anterior third has no peritoneum attached to it. Unless distended the rectum appears smaller than the colon, but is capable of great distention, especially in its lower third, where it is not covered by peritoneum. It is bounded *above*, by the sigmoid flexion of the colon; and *below*, by the anus: *anteriorly*, by the bladder in the male, from which it is separated by small intestines, which fall into the *cul de sac* formed by the peritoneum as it is reflected from the posterior surface of the bladder to the fore part of the rectum; it has also anterior to it the vesiculæ seminales, and the prostate gland; in the female it has before it the uterus and the vagina, from which however it is separated, as from the bladder in the male, by the small intestines: *posteriorly*, it lies *above*, upon the sacrum and os coccygis, connected to the former by the meso-rectum,—between the folds of which are placed the hæmorrhoidal vessels and nerves; and *below*, it rests upon the levator ani muscle: *laterally*, the rectum is covered by cellular membrane, and the levator ani muscles.

The extent and relative position of the alimentary canal

being perfectly understood by the pupil; the next step should be, before these organs are removed for the purpose of studying their form, structure, and organization,—to learn the extent and reflections of the splanchnic serous membrane which gives these, and the parietes of the abdomen, a more or less general covering. This could not have been traced before, without so displacing the intestinal canal as to render it impossible to demonstrate the natural position of the different viscera.

The *peritoneum* has derived its name from the Greek word *περιτεινω*, to surround; but which, however, it does not do, only giving a partial investment, always leaving some portion of every organ uncovered, for the entrance of its vessels and nerves; these, therefore, do not penetrate this membrane to pass to the different viscera, but are enclosed between its folds as it is reflected from one organ to another. Like all the serous membranes, the peritoneum forms a closed bag, without any external opening; and if it could be dissected from the different viscera and parietes of the abdomen without being cut into, it would be a large empty bag, but which presents an irregular surface within the abdomen from the numerous folds, processes, and prolongations it makes, partially enclosing the various and irregularly formed organs. Some idea, perhaps, may be gained of the course and attachments of this membrane, by supposing an opening to be made into the abdomen, and a quantity of colored varnish to be poured in, and the body to be shaken; the varnish being allowed to dry, upon inspection it would be found to have given a polished surface to the parietes of the abdomen, and to every surface of the viscera to which it would become applied: thus shewing the extent of the peritoneal surface.

The peritoneum presents an exterior rough surface, which is attached to the parietes of the abdomen, and to the viscera, by cellular membrane; and a smooth internal secreting surface, which is continuous throughout its whole

extent, and may be traced without interruption,—the visceral smooth portion being opposed to the parietal, while its secretion lubricates the surfaces so as to prevent friction.

The best mode of tracing the peritoneum throughout all its attachments is, by reflecting the anterior parietes of the abdomen, which have already been described as being cut through by two incisions, commencing from the umbilicus and extended to the anterior and superior spinous processes of the ilia. On the posterior surface of this triangular flap, the peritoneum will be seen passing downwards towards the pubes, and extending laterally along the inner surface of the fascia transversalis, into the iliac regions; tracing it downwards, and remarking at the same time the three cords which are placed between it and the parietes of the abdomen, we shall observe how it becomes reflected posteriorly to these cords on to the fundus of the bladder, leaving the anterior surface of the bladder, and a space between it and the pubes, uncovered;—a point of surgical importance, as in this situation, in retention of urine the bladder may be punctured above the pubes, without injury to this splanchnic serous membrane. It is from thence continued backwards, along the posterior region, and the posterior half of the lateral regions of the bladder, as far as the bases of the vesiculæ seminales; and then quits this organ to be reflected upon the rectum, leaving a pouch between the two, into which the small intestines usually fall. While the peritoneum is covering this portion of the bladder, it is bounded above by the urachus, laterally by the remains of the umbilical arteries, and below and in front by the vesiculæ seminales and terminations of the ureters. The portions, also, which extend laterally from the sides of the bladder into the iliac fossæ, are worthy of particular examination, from the two pouches which they form; the inner one between the bladder and umbilical artery, leading directly towards the external ring, while the outer one, between the umbilical arteries and iliac fossa, is directed towards the internal ring by the spermatic cord. It is these portions of peritoneum

which form the hernial sacs in direct and oblique inguinal herniæ.

The peritoneum then comes in contact with the anterior surface of the middle third of the rectum, extending up as high as the junction of the third and fourth pieces of the sacrum, where it winds around the sides of the intestine to form the meso-rectum, and retains this name as high as the sacro-lumbar articulation; where, as it leaves the sacrum, it runs up to the fourth lumbar vertebra, stretching out on either side to tie down the cæcum and colon in the iliac fossæ. From the upper part of the fourth lumbar vertebra, this membrane leaves the spine and passes forwards to surround the small intestines forming the posterior layer of the mesentery; and then winding around their convex edges and anterior surfaces, passes back again to the second lumbar vertebra;—thus forming the anterior layer of the mesentery, and extending laterally into the lumbar regions to tie down the ascending colon on the right side, and the descending colon and kidney on the left side. It may be observed, therefore, that the mesentery extends from the fourth to the second lumbar vertebra; being, below, continuous with the right and left lumbar and iliac meso-colon, enclosing all the convolutions of the small intestines. The anterior layer of the mesentery then passes downwards and forwards from the second lumbar vertebra, to the under surface of the transverse arch of the colon; forming the united root of the mesentery and meso-colon, behind which, and between it and the second lumbar vertebra, the duodenum crosses, to terminate in the jejunum. When this layer has arrived at the convex edge of the transverse arch of the colon, to which it is firmly attached; it leaves that intestine, and passes downwards in front of the small intestines, and consequently in front of the anterior layer of the mesentery; and in this situation forms the posterior layer of the great omentum, extending, as has been before observed, to a greater or less distance, in different individuals, downwards towards the pelvis. It then

turns forwards upon itself, and passes upwards; thus producing a kind of bag, the surfaces of which, however, are not in contact: this reflected portion forms the anterior layer of the great omentum, and passes upwards in front of the transverse arch of the colon, but *not* in contact with it, as high as the stomach,—the convex edge and anterior surface of which it now covers and adheres to; extending laterally on the left side to cover the spleen, and on the right side the anterior surface of the duodenum, and the vessels passing between it and the liver: from the smaller curvature of the stomach, it passes behind the left lobe of the liver to the diaphragm,—in this extent forming the anterior layer of Glisson's capsule, and of the less omentum; and having reached the diaphragm, it becomes reflected from it upon the concave under surface of the left lobe of the liver; and in the short space between the diaphragm and obtuse edge of the left lobe, it forms the inferior layer of the left lateral ligament of the liver. It continues to pass from behind to before, along the under surface of the left lobe to its acute edge, over which it turns and spreads, both right and left, to give a covering to the superior convex surface of the right as well as the left lobe of the liver; but at this point, in passing from the left to the right side, the peritoneum envelopes the remains of the umbilical vein, and forms the round ligament of the liver; while in passing backwards, covering the superior surface of both lobes of the liver, and connecting it with the diaphragm, it forms the suspensory ligament, which separates into two layers on the obtuse edge of the liver,—one layer passing to the diaphragm on the left side, to complete the left lateral ligament of the liver, and the other on the right side, to form the superior layer of the right lateral ligament. The triangular separation of the two layers of the suspensory ligament, is termed the coronary ligament. The peritoneum then proceeds as a wide extended continuous membrane upwards, from the obtuse edge of the liver, upon the concave surface of the diaphragm; from thence upon the anterior parietes of the

abdomen, down to the umbilicus, from whence we began our description.

The student should now well consider this description, and trace the peritoneum in the foregoing order, by raising the organs separately, and examining carefully the attachment of the peritoneum to the spine; during which examination, he will naturally discover that he has not yet learned how the ducts from the liver, the hepatic artery, and vena porta, are enclosed in peritoneum; how the covering to the posterior surface of the upper transverse portion of the duodenum, to the concave surface of the right lobe of the liver, to the anterior surface of the pancreas, to the posterior surface of the stomach, and to the anterior surface of the transverse arch of the colon are formed; together with the posterior layer of the lesser, and the two inner layers of the great omentum.

To understand this, he must again examine the anterior layer of the great omentum, where it covers the superior or anterior surfaces of the stomach; from the small curvature of which a layer has been described as passing upwards, behind the left lobe of the liver; but from the right side of the stomach, a portion of this same layer proceeds upon the anterior surface of the duodenum, the hepatic artery, vena porta, and ductus communis choledochus, underneath which there is an opening, termed the foramen of Winslow: through which opening this portion of the peritoneum passes, and in consequence of being pushed through a hole, forms a kind of pouch, presenting therefore two layers; this pouch is prolonged upwards to cover the under surface of the right lobe of the liver, reaches the diaphragm, and there forms the inferior layer of the right lateral ligament to the liver; it then passes downwards upon the spine, covering with its posterior portion the pancreas, and with its anterior the inferior surface of the stomach, and of the first third of the duodenum. The pouch, consequently the two layers, then pass forwards and downwards from the stomach to the anterior surface of the transverse arch of the colon, with

which the posterior layer is in contact; below this intestine they still continue downwards, between the posterior and anterior layers of the great omentum, and complete the four layers of that process of the peritoneum;—three of which layers are anterior, and one posterior, to the transverse arch of the colon. That portion of the peritoneum which surrounds the hepatic vessels and duct, is termed Glisson's capsule; and contains the hepatic arteries to the left, the hepatic ducts on the right, and the vena porta on a plane behind and between the two.

It should further be observed how the peritoneum, in being reflected towards the spine from the different organs which it covers, leaves a space between its layers for the passage of the vessels and nerves to the viscera; and how completely every viscus is situated externally to this closed sac. Between the layers of the mesentery the lacteals should be observed, directing their course upwards, and rather obliquely to the right, towards the right crus of the diaphragm to terminate in the thoracic duct.

Having finished the reflections of the peritoneum, and having already described the relative position of the stomach and intestinal canal, we may now proceed to remark the situation of the liver, pancreas, and spleen, and their connections with the organs of digestion.

The *relative position of the liver*:—this is the largest gland in the body, and occupies a considerable portion of the epigastric region of the abdomen: its right side or large lobe is placed in the right hypochondriac region, above the duodenum and ascending colon; the notch or division between it and the left lobe, is placed in the scrobiculus cordis; and its smaller left side or lobe, occupies a part of the left hypochondriac region. The liver is bounded *above*, by the diaphragm; *below*, by the stomach, and pancreas; in the *centre*, by the duodenum and ascending colon on the right side, spleen and descending colon on the left: *behind*, by the spine, crura of the diaphragm, aorta, thoracic duct, vena azygos and vena cava; in *front*, by the ensiform carti-

lage, and parietes of the abdomen; and *laterally*, by the cartilages of the false ribs. The duct of the liver passes from about the centre of its under surface to enter at the angle formed by the junction of the middle vertical with the lower transverse portion of the duodenum; and in the space between the liver and the entrance of the duct into the duodenum, the finger may be passed through an opening termed the foramen of Winslow, which passes under the hepatic duct, vena portæ and hepatic artery; and allows of that reflection of the peritoneum which, surrounding these vessels, passes to cover the pancreas and posterior surface of the stomach. It is this duplicature which constitutes the capsule of Glisson, containing, besides the hepatic artery to the left, the hepatic duct to the right, and the vena portæ in the middle, but on a plane posterior to the two; absorbent vessels, and the hepatic plexus of nerves, which surround them.

The *relative position of the pancreas.*—To expose this organ, the liver should be raised, the stomach drawn downwards, and the layers of the less omentum torn through. It is a long narrow viscus, placed obliquely across the abdomen, in front of the junction of the last dorsal with the first lumbar vertebra, crossing the lower and posterior part of the epigastric region. It is bounded in *front*, by the stomach and less omentum; *behind*, by the crura of the diaphragm, vena cava, aorta, and superior mesenteric artery: on the *right*, by the duodenum; on the *left*, by the spleen: *above*, by the cœliac and splenic vessels; and *below*, by the superior mesenteric artery, which separates it from the third portion of the duodenum. The duct of the pancreas opens into the duodenum in common with the ductus communis cholodechus, but cannot be traced until the organization of the pancreas is examined.

The *relative position of the spleen.*—It is deeply seated in the left hypochondriac region; bounded in *front*, by the left extremity of the stomach; *behind*, by the larger muscle of the diaphragm, corresponding to the ninth, tenth, and eleventh left ribs; to the *right*, by the pancreas; *below*, by

the descending colon and capsular renalis; and *above*, by the left lobe of the liver and concavity of the diaphragm. It is connected to the diaphragm and stomach by the reflections of the peritoneum, in consequence of which it is subjected to the motions of these parts.

Having observed the relative position of the organs of digestion, with their assistants the chylopoetic viscera, within the cavity of the abdomen; they may now be removed from the body, in order to examine their structure and organization. As this investigation should be rendered consistent with a physiological view of their functions, I shall give them in the following order: first, the œsophagus, stomach, and duodenum; then proceed to the liver, pancreas, and spleen, previously to the remaining portion of the intestinal canal,—it being subservient tó the function of the above-named organs.

It will be observed, I have here named the œsophagus, the principal part of which is contained within the cavity of the thorax; but as a portion of it is also contained within the abdomen, and as it forms a part of the digestive apparatus, its intimate structure and organization cannot be given at a better time than the present: leaving the minuter description of its relative position within the chest, until we speak of the contents of that cavity.

Structure of the œsophagus.—The œsophagus is a muscular canal, lined by a mucous membrane. It commences from the lower part of the pharynx, opposite to the fifth cervical vertebra; passes through the posterior part of the cavity of the chest, enters the abdomen through the crura of the diaphragm, and to the left of the tenth dorsal vertebra, terminates in the stomach at its cardiac extremity.

This organ is composed of two coats: an outer, which is muscular; and an inner, which is membranous. The *muscular* coat is formed of two planes of fibres passing in opposite directions; the fibres of the external layer pass in a longitudinal direction, arising in part from the cricoid cartilage of the larynx, in greater abundance anteriorly and

posteriorly, than at the sides, where they are less abundant, and the inner plane of circular fibres may be observed.

The longitudinal fibres are continued along the whole length of the canal; and diverging upon the stomach, are lost on that organ.

The circular fibres, or inner muscular plane of the œsophagus, pass in a transverse direction, having frequent interruptions in the portions of the circles they describe; as they reach the stomach, they become paler, and here terminate.

The *mucous* coat is a soft, spongy, whitish membrane, continuous above with that of the pharynx; but there appears to be a line of demarcation between it and the mucous membrane of the stomach below; it is furnished with a distinct cuticular covering, continued from that lining the mouth: in the human subject, it terminates at the cardia, in a sort of fimbriated border; but in some animals, it proceeds to line one half of the stomach. This interior coat of the œsophagus presents numerous longitudinal folds, which are produced by the contractions of its muscular parietes, and which must tend to facilitate the dilatation of the organ upon the passage of food. The muscular and mucous coats of the œsophagus, are connected with each other by a dense layer of cellular membrane, but which never contains adeps; it is found continuing itself into the folds of the mucous membrane, and constitutes the "tunica nervea" of the older writers. Mucous follicles are interspersed along the œsophagus in this cellular tissue; they resemble those of the pharynx, but are less numerous: they present minute open mouths in the furrows between the longitudinal rugæ, and are surrounded by the villi of the mucous membrane. The œsophagus, when empty, does not retain its cylindrical form, but is flattened from before to behind, when it produces transverse as well as the longitudinal rugæ. It is said by some anatomists to represent a double cone, the apices of which are connected in the centre, and the bases form the two extremities. This canal is supplied with blood by the

inferior thyroideal artery in the neck, by the bronchial arteries and the aorta in the thorax, and by the phrenic and coronary arteries in the abdomen; the blood is returned by the corresponding veins. Its absorbents pass to the surrounding ganglia; and its nerves form a plexus, which is continued along the whole course of this organ to the stomach: they are derived from the pharyngeal and pulmonary plexus, the cardiac, the ganglia of the sympathetic, and the pheumo-gastric nerves, with their recurrent branches.

Practical Remarks.

The œsophagus, equally with other parts of the body, is very liable to inflammation, not only from a general tendency to disease, owing to its high degree of organization, but also from the peculiar function which it is destined to perform: thus it is exposed to numerous exciting causes from the various substances which are swallowed. When inflamed, the mucous coat assumes a redder color than natural, has a pulpy appearance, and an increased degree of sensibility. A specific inflammation is supposed to be produced in the membranes lining the œsophagus and pharynx, from the bites of rabid animals, and which extends from the œsophagus to the coats of the stomach.

Stricture of the œsophagus, may arise from spasmodic affections of the muscular coat; from adventitious formations in the cellular membrane connecting the muscular and mucous coats; or, from diseases of the mucous membrane itself. Obstructions, from the two latter causes, require the use of the œsophageal bougie, as well as medical treatment, —which, in all cases, must be regulated by the peculiarities of constitutional circumstances.

Difficulty of swallowing, may also arise from a paralytic state of the muscular fibres of the œsophagus, which is principally denoted by the absence of pain, of any hardness, and of swelling in the course of the gullet,—through which a probang also passes without any impediment. The principal object in this disease is, to supply the patient with a sufficient quantity of food by means of a hollow bougie; the medical treatment being the same as in other paralytic affections.

Tumours in the neighbouring organs and tissues, may press upon the œsophagus, and produce dysphagia; this sometimes occurs from enlargements of the thyroid gland, aneurism of the arch of the aorta, and even from the formations of matter between the œsophagus and trachæa. The indications in each of these cases, will be obvious from the individual symptoms.

Foreign bodies frequently lodge in the œsophagus, either during deglutition,—from the peculiar texture, form, or hardness of the bodies swallowed; or from accidental causes. The effects produced, depend upon the part of the œsophagus in which they are lodged; when just at the commencement of the œsophagus, they endanger suffocation from pressure on the glottis: in these cases, an attempt should always be made to abstract them; for which purpose the finger may usually be employed, but sometimes it is requisite to use curved forceps. When bodies are lodged lower down in the œsophagus, if substances capable of being digested, they may be pushed into the stomach by a probang; but if the substance be of a nature to produce injurious effects in the stomach, attempts should be made to extract them; and even it may be necessary to resort to the operation of œsophagotomy.—It is here proper to mention, that great care is required in passing instruments into the œsophagus, not to mistake the opening into the glottis for the passage into the œsophagus: this accident is very liable to occur when the tongue is drawn forwards,—a mode recommended by some high authorities, but which I feel disposed to condemn; for when the tongue is drawn forwards, it raises the epiglottis, and leaves the passage into the larynx exposed to an ill-directed probang.

Organization of the stomach.—To examine this organ, and its relation to the chilopoietic viscera, it may be removed from the abdomen with a portion of the œsophagus, together with the duodenum, liver, pancreas, and spleen. The stomach is the organ of chymification, and consists of a large bag or pouch in which the food is received for that particular purpose. The form of the human stomach is best seen when distended with air; its general figure is that of a curved cone, the base of which is placed to the left, and the apex in a diagonal direction, downwards to the right. It presents a cardiac or splenic *left extremity*, communicating with the œsophagus; a pyloric *right extremity*, opening into the duodenum; two *curvatures*, the upper and posterior of which is the lesser, and is concave; the lower and anterior is the greater, and is convex: two *surfaces*, an anterior or superior, and a posterior or inferior. The stomach is composed of three coats, a peritoneal, a muscular, and a mucous or villous.

The *peritoneal* is the exterior covering, and is derived, as

has been before observed, from the anterior layer of the great omentum, which covers its anterior and superior surface; while the duplicature which passes behind the hepatic vessels to form Glisson's capsule, covers the posterior or inferior surface of the organ. This coat adheres firmly by a short, dense, cellular tissue to the muscular coat, excepting at its curvatures, where spaces are left for the entrance of vessels and nerves; these spaces also contribute to the more ready distention of the organ.

The *muscular coat* is composed of fibres, much whiter and thinner than those of the œsophagus, and pass in three different directions. The superficial fibres pass in a longitudinal direction, and are continued from the external coat of the œsophagus, principally along the two curvatures of the stomach, being more apparent and stronger on the lesser curvature, especially towards the pyloris; the few which expand upon the two surfaces, are whiter and more irregular in their course. The second set of muscular fibres pass in a circular direction over the whole stomach; they commence at the left extremity, where they take a parallel course in an annular direction; never however completely encircling the viscus, but are lost or intermingle with each other: they are strongest at each extremity, and in the centre; in which latter situation they sometimes cause an hour-glass contraction of the viscus, which has led some physiologists to the belief that the left half was destined to receive the solid parts of food, and the right the more fluid. The third set consists of two broad bands of oblique fibres,—one extending from the left side of the cardia over the surfaces, and the other from the right side of the cardia over the great extremity; this layer seems as if it were continuous with the circular fibres of the œsophagus. A layer of dense cellular tissue unites the muscular fibres to the mucous membrane, and has been considered by some anatomists as a distinct coat.

The *mucous membrane*—or third coat of the stomach. To expose this coat, the stomach should be opened along

its greater curvature, so as to preserve the cardiac and pyloric orifices.

The mucous membrane will generally be seen to be of a pale red color; frequently, however, it varies in its appearance, presenting patches of a dark brown or grey color, which are not to be mistaken for disease,—as they are found to exist without any previous symptoms of ill health which were likely to have produced them. The mucous coat of the stomach is disposed in numerous rugæ, differing in their size and appearance from those of the œsophagus; they take an irregular direction, oblique and transverse, apparently in some measure conforming to the action of the muscular coat. Between the rugæ of the mucous membrane in the course of the curvatures, by the aid of a microscope may be seen several little openings, formed by the excretory ducts, of small mucous glands, which are placed in the cellular membrane external to the mucous coat; these glands are termed the "Glandulæ Brunnerii:" there are also numerous other small perforations found on the mucous surface of the stomach, particularly about its two orifices, which are the openings of Peyer's follicles. The whole inner surface of this coat is covered with an abundant viscid secretion, as well as that peculiar solvent fluid which is termed the gastric juice. The entrance of the œsophagus and pyloric opening should now be carefully examined; for it will be found, when speaking of the process of chymification, that the functions of the stomach depend much upon these orifices being closed; for which purpose we shall find a peculiar construction. The œsophageal or cardiac orifice is situated at the left extremity of the smaller curvature of the stomach, at the junction of the two right with the left third of the upper portion of that viscus; the large *cul de sac* formed by the splenic extremity of the stomach, being entirely to its left. The termination of the œsophagus into the stomach does not form a circular opening, but an orifice, directed obliquely forwards and slightly to the left; so that if a transverse

section were made of the stomach, the anterior half of the organ would retain three-fourths of the œsophageal orifice; which arrangement tends to prevent regurgitation of the food, and offers a greater obstacle as the stomach changes its position, when thrust forwards from the accumulation of food. This cardiac opening is placed to the left of the tenth dorsal vertebra.

The pyloric orifice is produced by the termination of the stomach into the duodenum, at the junction of the scrobiculus cordis with the right hypochondriac region, immediately to the right of the twelfth dorsal vertebra. This end of the stomach becomes more and more contracted as it approaches the duodenum, and forms a conical extremity which enters the intestine, the commencement of which envelopes the apex of the pylorus. At this point the pylorus is contracted by a circular rim, which is flattened and perpendicular to the walls of the orifice, and has been termed by some anatomists, the valve, and by others the muscle of the pylorus. It is of a whitish color, and four times the thickness of the muscular coat of the stomach, it appears to possess a remarkable power of resisting the passage of aliment from the stomach, until it has undergone the changes produced by the process of chymification. The position of the stomach, in its distended state, may offer some resistance to the free passage of its contents, but does not appear to be the sole cause of its retention; which is verified by the following experiment:—When the stomach of a living animal is dilated with air from the œsophagus, it will suffer considerable distention before the air passes through the pylorus: on the contrary, air passes readily when blown in from the duodenum. Whether this power is attributable wholly to position, or depends upon the muscular contraction of the valve, appears to be a subject fully worthy of further research.

Organization of the duodenum.—The duodenum is larger, thicker, and capable of greater distention, than the other small intestines. As before observed, it is only partially

covered with peritoneum, to which this greater distensibility is attributable; and which has led some authors to consider it, as a second, or subsidiary stomach. The fact, that when food has passed from the stomach not perfectly chymified will be returned through the pylorus, would seem to point out a power in the duodenum, which places the digestive apparatus of man, an omniverous feeder, as a link between the most complicated structure of the ruminating, and the more simple apparatus of the carniverous animals.

The *peritoneal coat,* gives a covering to both surfaces of the upper transverse third of the duodenum, and only an anterior covering to the middle, vertical, and inferior transverse third.

The *muscular coat,* is formed of strong fibres passing principally in a circular direction, although some few longitudinal fibres may be observed on its superior transverse portion.

The duodenum should now be cut open on its upper surface, to expose its internal *mucous coat;* which is a continuation of that from the stomach. It is reddish, soft, and presents innumerable villi, around which there are openings from the mucous follicles placed within the cellular membrane connecting the mucous with the muscular coat; these follicular openings are more distinct here than in the stomach. The mucous membrane of the duodenum presents a very extensive surface, disposed in numerous folds lying one over the other; these are called the valvulæ conniventes: which not only retard the quick passage of the food through the intestine, but are for the purpose of presenting a larger absorbent surface, or distribution of the lacteals. At the point of union of the vertical with the lower transverse third of the duodenum, a small tubercle or papilla perforates the mucous membrane, for the common termination of the biliary and pancreatic ducts, which renders the duodenum a most important part of the alimentary canal.

The *arteries* of the duodenum, are derived from the hepatic branch of the cæliac; from the pyloric, right inferior gastric,

and superior mesenteric. Its *veins* correspond with the arteries: the *nerves* are distributed from the solar plexus: its *absorbents* pass to the ganglia situated immediately above the pancreas.

The importance of the secretions furnished from the chylopoetic viscera, and the remaining portion of the intestinal canal being subservient to their united actions, it seems more consistent with the physiology of digestion, to describe the liver, pancreas, and spleen, next to the duodenum.

Organization of the liver.—The relative position of this organ within the cavity of the abdomen having already been described, we may at once proceed to give an account of its structure. This is the largest of the glands; its weight, in the adult, is about four pounds, or one-sixteenth of the whole weight of the body; in the fœtus, however, it bears a much greater proportion. The liver is of a deep red, or brown color; compact in its texture, but easily torn when its peritoneal covering is removed: it presents an irregular quadrilateral figure, in which we distinguish a *superior convex surface*, an *inferior irregularly concave surface*, a *posterior obtuse*, an *anterior acute edge*, and *two lateral edges*, the right of which is the more obtuse. The superior convex surface is divided into two unequal halves by the suspensory ligament, which we have already described as formed by a duplicature of the peritoneum serving to connect the liver to the diaphragm. The right larger half is termed the *right lobe*,—on the surface of which nothing is presented worthy of remark, beyond its general convexity; the *left* side, or *smaller lobe*, presents less convexity, and is directed rather more upwards than the right. The under concave surface, in a like manner to the superior, is divided into a large right and a small left lobe, the division being marked by a deep fissure, which passes in the short diameter of the organ from before to behind. The concavity is irregular, and does not correspond to the convexity of the superior surface. On the concave surface of the right lobe are distinguished three elevations, of the substance of the gland;

termed, lobulus spigelii, lobulus caudatus, and lobulus quadratus.

The *lobulus spigelii,* somewhat of an oblong figure, is situated at the inner and back part of the right lobe; it is placed between the vena cava on its right side, and the remains of the ductus venosus on its left: at the posterior part it forms a portion of the obtuse edge of the liver, and at its lower anterior part it is bounded by the porta or transverse fissure.

The *lobulus caudatus,* is a projected elevation, which passes from the anterior extremity of the lobulus spigelii diagonally forwards, and to the right, and is lost in the substance of the right lobe; in this passage, it forms a boundary to the porta of the liver.

The fifth lobe, or *lobulus quadratus,* is that portion of the right lobe of the liver which is placed between the gall bladder and the anterior half of the longitudinal fissure, having the porta behind it; while, anteriorly, this lobe forms a part of the acute edge of the gland. Sometimes a portion of greater or less extent passes from this lobe across the longitudinal fissure, to be connected with the left lobe, and forms what is termed the pons hepatis.

Fissures of the liver.—The first is the *longitudinal,* which divides, as before mentioned, the lower surface of the liver into two unequal lobes, extending from the anterior to the posterior edge in its short axis. This fissure may further be divided into two, at the point where it crosses the left extremity of the porta at right angles. The anterior half may be termed the *umbilical fissure,* from its containing the remains of the umbilical vein; while the posterior half may be termed the *fissura venosa,* from its containing the remains of the sinus venosus.

The *transverse fissure,* forms the porta of the liver, which passes in its long axis from side to side, and is placed about the centre of the organ: it is bounded behind, by the lobulus spigelii; before, by the lobulus quadratus; on the right, by the lobulus caudatus; and on the left, by the longitudinal

fissure. This fissure is termed the porta, from its giving passage to the principal blood-vessels and the ducts of the liver, containing the same parts as are found in Glisson's capsule; namely, the hepatic arteries, hepatic ducts, and vena portæ. As the hepatic ducts pass out of the liver at the porta, they are placed between the artery and vein; but as the common duct passes forwards to the duodenum, as we have already observed, it is placed to the right of the artery and vein.

To the right of the lobulus spigelii, either a *fissure* or foramen is found for the passage of the vena cava; it passes in the direction of the short axis of the gland, and opens at the obtuse edge close to the diaphragm, through which this vessel passes to terminate in the right auricle of the heart. Immediately to the left of the vena cava, and superior to the lobulus spigelii, will be found the openings for the passage of the hepatic veins, which pass from the liver to terminate in the vena cava, at its passage through the diaphragm.

At the commencement of the longitudinal fissure, a notch may be seen upon the superior, as well as the inferior surface of the organ: this receives the round ligament, or remains of the umbilical vein, and forms the fifth *fissure* of the liver.

The under surface of the liver is further rendered irregular by numerous *depressions*, which seem as if they were produced by the pressure of the neighbouring organs. There are five of these, which may be principally distinguished: two upon the under surface of the right lobe; the one placed anteriorly to the other receives the colon, just where the ascending portion of that intestine becomes transverse; and the posterior depression is marked by the capsula renalis and right kidney. The left lobe has a similar depression for the descending colon, and another posterior to it for the large left extremity of the stomach and spleen.

A fifth depression is found immediately on the right of the lobus quadratus, of an oval form, which lodges the gall bladder; this depression is not covered by peritoneum, but is in contact with the parietes of the gall bladder.

The liver receives a general covering from the peritoneum, but is not completely surrounded by it in its whole extent; for at the posterior or obtuse edge there is a considerable space left between the two laminæ of this membrane, in which is found the vena cava and the terminations of the hepatic veins. A further use is attributable to this separation of the peritoneum, in allowing the liver to enlarge upon receiving an increased quantity of blood during the process of digestion.

The peritoneum covering the liver presents a transparent, smooth, and polished surface, which is constantly moistened with a serous fluid, and facilitates therefore the motions to which the organ is liable; it presents also a rough cellular surface, which is connected with the true cellular envelope of the organ. And further, the peritoneum not only gives this external covering to the liver, but forms several processes, which connect it with the diaphragm and parietes of the abdomen.

These processes are termed the *ligaments* of the liver, and are five in number. First, the round ligament, is the remains of the umbilical vein, which is found as an impervious cord running from the umbilicus, between the fascia transversalis and peritoneum, to the umbilical notch; and then proceeding along the longitudinal to the transverse fissure, is lost in the substance of the liver. The use of this cord after birth, may be considered principally for the purpose of attaching the liver to the parietes of the abdomen. Around this cord the peritoneum, as it passes from the convex surface of the left lobe, across to the right, winds around the round ligament; and then, being reflected upon the diaphragm, forms the *suspensory* ligament; — thus keeping the liver in its situation in the epigastric region. The suspensory ligament in its direction backwards, as it gains the obtuse edge of the liver, splits into two; or, more properly speaking, its two laminæ separate. At this point one is termed the *coronary* ligament, which passes right and left, from the obtuse edge of the liver to the diaphragm, and

forms the superior layer of the right and left *lateral* ligaments; the other, or inferior layer, being completed by the peritoneum, which is reflected from the concave surface of the liver to the diaphragm: these layers are considerably separated from each other, and leave therefore, as has been before described, the obtuse edge of the liver uncovered by peritoneum. These five connecting membranes, or ligaments as they are called, seem to maintain the liver in the epigastric region.

Underneath the peritoneum a second envelope is found, surrounding every part of the liver, and entering even into its very substance, by accompanying the branches of the hepatic artery and vena portæ; and by some anatomists is considered to form an extension of membrane for the ramifications of the different vessels which enter into the composition of the organ, so indeed as to produce the principal part of its parenchyma. This membrane also surrounds the hepatic ducts, and where it encloses the vessels the sheaths receive the name of Glisson's capsule. It does not give the same covering to the hepatic veins; hence these vessels, when divided, do not collapse, being firmly attached to the substance of the liver, while the other vessels contract and recede within their cellular capsules.

Having in this description attended to the circumstance of different vessels entering into the liver, it is necessary more particularly to describe them, and to mention that there are five sets: namely, the vena portæ and the hepatic arteries, to convey blood to the organ; the hepatic ducts, to convey the secretion from it; the hepatic veins, to return the blood into the circulation which is not consumed either for the secretion of bile or nourishment of the liver; and lastly, the absorbent vessels, which are for the same purpose as in other parts of the body, to remove that which is unfitted for the natural function of the biliary apparatus.

The *vena portæ* is produced by the junction of the splenic and superior mesenteric veins, which form a trunk smaller than the united diameters of the two. It takes a course

upwards and to the right, opposite to the junction of the last dorsal with the first lumbar vertebra; it then proceeds to the porta of the liver, and within the substance of the gland is distributed after the manner of an artery,—a circumstance in which it differs from every other vein in the body.

The *hepatic artery* is derived from the cæliac, after which it divides into a right and left trunk to be distributed to the respective lobes.

The *hepatic veins* arise from within the substance of the organ, form trunks which pass backwards towards the obtuse edge of the liver, where they pass out to terminate in the inferior cava.

The *hepatic ducts* form the excretory apparatus of the liver, and pass out, finally uniting in the transverse fissure; it reaches Glisson's capsule, through which it passes to the duodenum, receiving in this course the ductus cysticus of the gall bladder.

The *absorbent vessels* of the liver take two courses; one set terminates in the thoracic duct within the abdomen, the other perforates the diaphragm, ascending in the anterior mediastinum to enter the duct, near to its termination.

The student may here observe, that the liver has five lobes, five fissures, five depressions, five ligaments, and five sets of vessels.

The ultimate structure, or parenchyma of the liver, is to be observed by cutting into or breaking down the structure of the organ. It presents a granular surface, formed of minute kidney-shaped bodies, of a reddish yellow colour, being connected with each other by a brown cellular texture. From the innumerable ramifications of the blood-vessels and biliary ducts, the torn surface of the liver presents a cellular appearance. If a portion of the liver be kept in pyroligneous acid for about two months, this granular structure is rendered more evident; each small lobule will be separated, assuming various forms, generally resembling minute kidneys, having vessels connected to them in a sort

of fissure, exactly resembling the kidney itself. The same appearances may sometimes be observed from the formation of tubercles, when they reach the surface of the gland, when these lobules become separated from their connecting cellular membrane. These little granules appear to receive the different sets of vessels distributed to the organ; but some difference has been observed in the mode of their intimate connection, upon which depends the function of the secretion of the bile. Let us first believe the granule as the proper glandular apparatus. To it we find blood supplied from two sources, namely, from the hepatic artery and vena portæ; the secreted product is conveyed from the granule by the hepatic duct, while the blood not exhausted either by the formation of the bile or nourishment of the liver, is conducted into the due course of the venous circulation by a branch of the hepatic vein. These are the facts observed in the minute structure; and without entering into the controversy of whether bile is furnished solely by the vena portæ, by the hepatic artery, by both, or by the particular action of the granule itself independent of either; it need only be observed, that the greater proportion of the principles constituting bile, is furnished by the vena portæ. It has long been, and is yet, a matter of controversy, whether the bile is furnished from materials supplied by the hepatic artery, or vena portæ: those who contend for the artery observe, that the proportion of secretion is in proportion to the quantity of blood supplied by the artery; and further, that the quantity of arterial blood is greater than would appear necessary for the mere nourishment of the gland itself: while those who contend for the vena portæ, dwell on the fact of the elements of the bile being found in the greatest abundance in the blood of the vein: at the same time it may be observed, that the vital energy of the portal ramifications must be very great, being plentifully supplied with nerves from the semilunar ganglia.

The secretion of bile, however, does not seem absolutely

to depend upon the circulation of the vena portæ alone, from the fact of this vessel having been found to terminate occasionally in the vena cava inferior, when the supply of blood to the liver is solely derived from the hepatic artery, which in such instances has been invariably found of an unusually large size. When the hepatic ducts are tied, the liver becomes universally suffused with bile of a green hue; and ten hours after the experiment, matter is discharged from the anus of the same green tint. It seems therefore probable, that both artery and vein assist in the formation of the bile. The experiment of tying the vessels, and of throwing injections into them, proves an intimate connection between them, without furnishing any conclusive results. It seems, from the recent investigations of Dr. Mappes, of Frankfort, that the ultimate ramifications of both the vena portæ and hepatic artery meet in the little granules of the liver, and that the secretion is produced by these granules, —from which the radicals of the hepatic ducts arise. He further observes, that the hepatic artery and vena portæ appear rather to surround, than form an intimate visible connection with the granula; while, on the contrary, the hepatic vein is most intimately connected with the substance of the granule itself. He therefore concludes, that the hepatic vein has a principal office in effecting the separation of the bile; while the hepatic artery, and vena portæ, appear to perform a preparatory or conducting apparatus, previous to the elimination of the secretion by the proper vital action of the granule.

Besides the biliary ducts, the *gall bladder* is to be considered as part of the excretory apparatus of the bile, and as belonging to the liver, for the secretion of which it forms a reservoir. The gall bladder is an elongated pyriform pouch, which is connected with the anterior part of the right lobe of the liver, upon which a depression is formed to receive it. Its direction with respect to the short axis of the liver is not vertically, but obliquely placed, being directed forwards and to the right. As might be supposed from its pyramidal

form, it presents an apex and a base, and the centre of the organ is distinguished by all anatomists as the body.

The *body* of the gall bladder adheres to the depression formed for it on the right lobe of the liver, by its cellular coat, as well as by the ramifications of blood-vessels; but no ducts, nor any medium of communication can be traced between them, although it was formerly believed that ducts led from the one organ to the other. The *base* of the gall bladder usually projects beyond the acute edge of the right lobe of the liver; and presents itself to view upon the cavity of the abdomen being laid open, lying in contact with the commencement of the duodenum, which is usually colored by its exuded bile. The *apex*, which forms the neck of the gall bladder, is directed upwards, backwards, and to the left towards the transverse fissure; is narrower and slightly curved to become connected with its excretory duct, which empties itself in the hepatic duct.

The gall bladder has its parietes formed of three coats,—a serous or peritoneal, a cellular, and a mucous.

The *serous* or peritoneal coat, is derived from the anterior layer of the less omentum, and does not give a covering to the whole organ; for the upper part of the body which is connected with the liver, is deficient in this membrane.

The *cellular* coat surrounds the whole of the gall bladder, and produces the adhesion between it and the liver upon the upper part of the body; while through the rest of its extent, it connects its serous and mucous coats. If quick-silver be insinuated into the cells of this coat, the absorbent vessels may be injected.

This coat has by some anatomists been considered as muscular; they having been led to this supposition from the adaptation of the viscus to its contents, as well as from the power which it has been suppossd to exert, upon the application of artificial stimuli.

The *mucous* coat forms the interior lining of the gall bladder, and its duct. It is of considerable thickness, and of a whitish color, though generally found tinged with bile

soon after death. This coat is furnished, particularly about its neck, with numerous folds, which cross each other in various directions, having within them minute rugæ. Towards the neck and commencement of the cystic duct, these folds assume more of a valvular distribution, and have been described by Bichat as being arranged in a special direction. Upon the surface of this membrane are found numerous follicles, particularly about the neck; these probably secrete the mucus which is destined to defend the organ from the acrimony of the bile.

The gall bladder is not found in many animals possessing livers, as in the elephant, horse, rhinoceros, camel, certain cetacea, and some birds; it is found, however, generally in carnivorous feeders. Cuvier suggests, that its presence is connected with the necessity such animals have of fasting for a long time. In the human subject it is sometimes wanting, and in certain instances of calculi it has been found so filled with these concretions, as to be useless as a reservoir for bile: while, again, the ductus communis may be so pressed upon, as to prevent the discharge of bile into the duodenum; in which case, the gall bladder may become so distended, as to produce a prominent fluctuating tumour in the epigastrium. Instances have occurred in which these tumours have been opened, under the supposition of their containing matter; the result of which has been quickly fatal, from the escape of bile into the cavity of the abdomen. In other instances, the ductus cysticus only has been obstructed; when the gall bladder has been found filled with pure transparent mucus.

The union of the cystic with the hepatic duct, forms the ductus communis choledochus, which is about three inches long, passes between the lamina of the less omentum, in front of the hepatic arteries, which are placed between it and the vena portæ; it then descends behind the head of the pancreas and second portion of the duodenum, into which it enters, uniting with the pancreatic duct; passes between the coats of this intestine, and opens within it, an inch below

its first entrance, at a small mamillary projection, which presents the appearance of a membranous valvular fold.

These ducts are composed of two coats; the outer, cellular, and similar to that of the gall bladder; the inner, mucous, and furnished with several rugæ of a semilunar form. These are supposed to contribute to retard the course of the bile. Some anatomists have considered that the opening of the ductus communis into the duodenum, is furnished with a small sphincter muscle, which regulates the proper flow of bile in the process of digestion.

Nerves and absorbent vessels may be traced surrounding these ducts.

The Pancreas

Is deeply seated in the epigastric region. It is a long narrow gland, passing transversely from the duodenum on the right side, to the spleen on the left; presenting a convexity anteriorly, and a concavity posteriorly. It is bounded *before*, by the stomach and less omentum; *behind*, by the aorta, superior mesenteric artery, and vena cava; and is opposite to the junction of the last dorsal with the first lumbar vertebra. Its *superior* edge is intersected by the cæliae artery, and on the left assists in forming a groove for the passage of the splenic vessels. Its *lower* edge corresponds to the inferior transverse portion of the duodenum, from which it is separated by the superior mesenteric artery. Its larger *right* extremity, or head, is thicker and broader than the *left;* and has a smaller portion of gland connected with it, which is sometimes called the small pancreas. These are placed within the curvatures of the duodenum, sometimes a little overlapping the middle or vertical portion. The left extremity, or tail, is thin and narrow, reaching beneath the spleen, with which it is connected by peritoneum, as far as the left capsula renalis. This organ occupies a portion of the three divisions of the epigastric region.

Organization.—Its anterior surface is covered with peritoneum. Its parenchyma is of a reddish grey color, composed of a number of small lobes connected by a dense

cellular membrane, which gives it its peculiar firmness; each of these lobes are again divisible into minute granules, which give rise to the radicals of the excretory duct, and probably receive the ultimate termination of the arteries, and the origin of the veins. The excretory duct takes its course from the tail to the head, or from the left to the right, nearly in the centre of the substance of the gland, but somewhat nearer to its lower edge; being formed of the union of the minute branches, which are united with it in a penniform distribution. The duct increases in size as it approaches its termination; near which it is enlarged by the addition of a similar duct, which joins it from the less pancreas. It terminates at an acute angle in the ductus communis choledochus; or sometimes runs parallel with it, to open separately into the duodenum. Occasionally, though rarely, the less duct will also terminate separately.

The *duct* is composed of an internal smooth mucous membrane, covered by dense cellular tissue; it is more transparent than the excretory duct of the liver.

The *arteries* of the pancreas are very numerous, but of small size, and are distributed from the branches of the cœliac artery. Its veins terminate in the vena portæ, and particularly through the medium of the inferior mesenteric and splenic veins.

Its *nerves* are derived from the solar plexus, and its *absorbents* terminate in the pancreatic ganglia.

The size of the pancreas in the fœtus is not, as the liver, greater in proportion, but bears the relative dimensions of the rest of the body; in old subjects it becomes smaller, and of a darker color.

It is found of a large size in herbivorous feeders; and in different animals there is a considerable variety in the termination of its duct. This organ has been considered very similar to the salivary glands; but besides numerous anatomical distinctions, Tierdermann and Maling have discovered material analytical differences. They believe it to be the principal agent in chylification; while the bile only

colors the chyle, and is principally for the use of decarbonizing the blood. There seems indeed every reason to believe it to perform some important part in the digestive process, not perhaps essentially necessary, but requisite for perfect digestion; it has been removed from the lower animals without causing any particular distress.

The Spleen

Is placed in the left hypochondriac region, behind the large left extremity of the stomach; it is bounded *above*, by the diaphragm; *below*, by the left capsula renalis, and descending colon: in *front*, by the stomach; on the *left*, by the ninth, tenth, and eleventh ribs, and origin of the diaphragm; and on the *right*, by the pancreas. Its form is ovoid, its long axis, which varies from four to six inches, is placed vertically; its *upper* extremity is smaller than the lower; its *outer* surface is convex, corresponding to the concavity of the diaphragm; its *inner* is irregularly concave, and is marked by a fissure, into which its vessels enter to be distributed in the substance of the organ. There are often deep fissures on the edges of the spleen, and sometimes one or more smaller spleens attached to the larger one.

The spleen is furnished with two envelopes, or coats,—the external serous, and the internal fibrous.

The *serous* or peritoneal coat, gives a general covering to the organ, excepting at the bottom of the fissure, from the edges of which it is reflected and continuous, forming the attachment of the spleen to the stomach and the diaphragm.

The *fibrous* coat, is much more extensive than its serous; for it not only covers the periphery of the organ, but enters minutely into its substance, of which it forms a very considerable part. It may be seen entering the bottom of the fissure, accompanying and surrounding the vessels. It is of a greyish white color, dense and elastic. Blood-vessels can be traced to it; but its nerves have not yet been demonstrated.

The human spleen presents, in the recent subject, a greyish blue color, but which in a few hours changes to a purple hue, so as to resemble a mass of clotted blood; and it has a somewhat shining appearance, produced by the dark purple substance underneath its external white coat. When divided, the clotted mass is seen to be held together by threads of a white fibrous tissue. Upon washing away the clotted substance, the fibrous portion resembles a soft fine sponge, so transparent, that it is best seen when floated in water.

The splenic *artery* takes its rise from the cæliac, runs along the posterior surface of the upper edge of the pancreas in a remarkable tortuous manner, which tortuosity admits of the motions of the spleen with the stomach and diaphragm; but the spleen also receives some small arterial branches from the diaphragmatic, capsular, first lumbar, and spermatic artery on the left side.

The accompanying *vein* is somewhat larger than the artery; it is remarkable for the thinness and extensibility of its parietes; and like the other abdominal veins, it is not furnished with valves. The splenic vein forms the principal branch of the vena portæ.

The *absorbent vessels* of the spleen are large, and easily injected; they are divided into a superficial and deep-seated set, surround the splenic vessels, and passing through the hepatic ganglia proceed to terminate with the absorbents of the liver in the thoracic duct.

The *nerves* are separated from the solar plexus, and are termed the splenic plexus.

There has been great difficulty in assigning the proper office of the spleen; but its situation, its plentiful supply of blood-vessels from the cæliac artery, the origin of its nerves, and its attachment to the stomach, all tend to induce the belief that it performs some important office connected with the process of digestion. Whatever this function may be, it appears one which may be compensated for by the action of other parts. I have extirpated the spleen from several

animals, without observing any particular result, excepting in one instance, the omentum of a dog was particularly loaded with fat; and this animal, as well as several others, had a tendency to lose their hair, and had a mangy disposition in their skin. It may be worthy of remark, that rabbits subjected to this experiment seldom survive beyond a week or ten days; while dogs, with cautious feeding, seem to suffer but little inconvenience. May this in any way be connected with the difference of digestion between carnivorous and herbivorous feeders?

The termination of the splenic artery, and the commencement of its vein, have been variously described by different authors.

Some suppose the artery to terminate in cells, from which the veins arise. Others, that its minutest divisions terminate like the hairs of a pencil, without anastomosing with each other; around which the veins arise freely anastomosing. Its erectile power is attributed to this structure.

Sir Everard Home considers the spleen to be made up of an interlacement of arteries, veins, and absorbents, between which there is no cellular membrane, the interstices being filled with serum, and the coloring matter of the blood, which is poured out from the lateral orifices of the veins, when these vessels are in a distended state; and which serum is afterwards removed by the numerous absorbents belonging to the organ, and is carried into the thoracic duct by a very large trunk. He considers, therefore, the spleen to be a reservoir for the superabundant serum, lymph, globules, soluble mucus, and coloring matter of the blood, which is carried into the circulation immediately after the process of digestion.

Sir Astley Cooper for several years described the spleen, in his anatomical lectures at Guy's Hospital, as a reservoir for venous blood; possessing in itself the power of pouring its contents into the vena portæ by the inherent elasticity of its proper coat: and used to illustrate his opinion by distending the spleen with water, and then by puncturing the

fibrous tunic, the fluid was forced out of the organ, forming a complete *jet d'eau,* until perfectly emptied.

Minute whitish bodies are dispersed numerously through the substance of the gland, the nature of which is unknown. The whole substance of the gland admits of minute injection, which is found to pass readily from the arteries into the veins.

What change the blood undergoes in the spleen, is unknown; but it has been observed, that the chyle in the thoracic duct, above the entrance of the absorbents of the spleen, differs from the chyle in the mesenteric absorbents, in its greater power of coagulation, and a closer resemblance to blood; from which it has been concluded, that this organ is essential to chylification. This view of its office is supported by the fact, that in the fœtus the spleen is small, at which time no chyle is found in the intestinal canal; whereas after birth, when the assimilation of alimentary matter commences, the viscus is found full of blood, and increases rapidly in size. A further corroboration of its use in assimilation, is derived from the circumstance of the spleen being found full of blood in animals which have been starved to death.

The pathology of the spleen has not afforded any light as to the nature of its function, although it is frequently found diseased, and particularly in protracted cases of intermittent fever.

We have next to give a particular account of the organization of the remaining portion of the intestinal canal. This consists of the jejunum and ileum, small intestines; and of the cæcum, colon, and rectum, forming the large intestines. For their relative position *vide p.* 39.

The *jejunum* and *ileum* constitute the greater length of the intestinal canal, and fill the greater part of the umbilical and hypogastric regions. Their division is arbitrary; but anatomists have assigned two-fifths of their length to the jejunum, and the remaining three fifths to the ileum: they are tied to the spine by that process of peritoneum which is

termed mesentery. This process forms a bed for the distribution of the numerous vessels passing to and from the small intestines; and is so disposed as to allow of the frequent convolutions in which they are arranged. The small intestines are distinguished from the large by their general smooth and shining surface, and by their cylindrical form only being interrupted by the bendings of the convolutions. Like the stomach and the duodenum, they are composed of three coats. First, the *serous,* or peritoneal coat, which gives them a general outer covering, leaving a space between the two layers forming the mesentery, for the entrance of their vessels and nerves, and to allow of their distention. There is also found between the layers of the mesentery, numerous small glands, which are termed the mesenteric ganglia.

The *muscular* coat, is not so thick as in the duodenum; but is arranged in the same manner, in longitudinal and circular fibres. The *longitudinal* fibres are external, and most perceptible along the convex edge of the intestine. These fibres are not continued through the whole length of the intestine, but have frequent interruptions. The *circular,* or internal fibres, are more apparent than the external, are pale in color, and pass in a transverse direction; never, however, forming a complete circle, but, like the longitudinal, have frequent interruptions, from which fresh fibres commence.

The *mucous* or *villous* coat, is paler than in the stomach, and forms itself into numerous folds, which encircle about three-fourths of the calibre of the intestine; these are broader in their middle, pointed or bifid at their extremities, and are imperceptibly lost by uniting with other folds. These duplicatures are termed the valvulæ conniventes, and are found most numerous in the jejunum; their use is to afford an expanded surface for the distribution of the lacteals, and at the same time to arrest the progress of the aliment for the purpose of its absorption. On the surface of the valvulæ conniventes are found numerous little pro-

jections, forming fringes, which are composed of numerous villi; and if these be subjected to microscopic observation, numerous perforations are discovered, which are the absorbent mouths of the lacteals.

Between the muscular and mucous coat of the intestines, in the cellular membrane which connects the two, are numerous mucous follicles, which open into the intestine in the interstices between the valvulæ conniventes; they are in some situations found in clusters, particularly near the termination of the ileum, and are termed the glandulæ aggregatæ or Peyeri; in other situations they are larger and isolated, and are termed glandulæ solitariæ or Brunnerii; these latter are more distinct in the duodenum, and upper part of the jejunum.

The *arteries* of the jejunum and ileum are derived from the convexity of the superior mesenteric artery; they take their course between the folds of the mesentery, and are remarkable for their frequent anastomoses; fifteen to twenty branches are first given off separately from the convexity of the superior mesenteric; these again unite, so as to form smaller convexities, from which minuter branches are distributed, again forming the smallest convexities, which ultimately send the minutest branches into the intestines.

The *veins* take the course of the arteries, and terminate in the vena portæ.

The *lacteals,* which are more distinct and numerous above than below, take their course between the layers of the mesentery, pass through the mesenteric ganglia and on the right of the second lumbar vertebra, between the right crus of the diaphragm and aorta, ultimately to terminate in the thoracic duct.

The *nerves* which accompany these vessels to be distributed to the intestines, are derived from the superior mesenteric plexus.

The term jejunum, has been adopted from the circumstance of the first portion of the small intestines being frequently found empty; but the jejunum may also be dis-

tinguished from the ileum by the greater number of its valvulæ conniventes, and from its being somewhat thicker, particularly near the duodenum.

The ileum terminates in the colon, in a peculiar manner, which will be mentioned with the anatomy of that intestine.

The remaining portion of the intestinal canal, forms one-fifth of its whole length, and is called the large intestines; for the relative position of which, *vide page* 40. They have certain characters that readily distinguish them from the small: these are their size, the inequality of their surfaces produced by numerous sacculated projections, and by the appendices epiploicæ—which are portions of adeps enclosed between the layers of the peritoneal coat.

Organization of the cæcum.—This intestine may be at once distinguished by its commencing in a *cul de sac* or blind pouch, and by its vermiform appendix. Its peritoneal coat does not give it a general covering, but leaves a considerable space posteriorly where it rests upon the iliacus muscle. Sometimes, however, a complete meso-cæcum or envelope is found.

The *muscular* coat is formed externally of three longitudinal bands, which commence from the vermiform process, and take their course at about equal distances, along the sides and posterior surface of the intestine; they are shorter than the intestine itself, from whence results the sacculated or puckered appearance of the cæcum, as well as of the other large intestines.

The inner layer of the muscular coat is disposed much in the same manner as that of the small intestines.

The *mucous* membrane of the cæcum, is peculiar in having three distinct openings on its surface; one into the ileum, one into the vermiform process, and a third into the ascending colon. It presents some indistinct folds, which have been termed its valvulæ conniventes; its villosities also are much less apparent than those of the small intestines. The mucous follicles are very numerous, but isolated.

The valvular opening of the ileum into the cæcum, is

produced by the mucous membrane and circular fibres of this small intestine projecting into the large. This junction forms nearly a right angle; consequently, the projection of the ileum into the cavity of the cæcum, presents an upper and an under fold; the superior being termed the ileo colic valve, and the inferior the ileo cæcal,—which latter is larger than the upper, in consequence of the slight obliquity of the entrance of the small intestine. This inferior fold prevents regurgitation from the cæcum; and the superior fold (which is placed more transversely), from the colon. These folds are united at their extremities; and from each junction or commissure, a prominent fold is continued round the inner surface of the cæcum, forming retinacula or frena; in consequence of which, distention of the cæcum tends to close the entrance into the ileum. The peritoneal and longitudinal fibres of the muscular coat of the ileum, are continued upon the parietes of the cæcum.

The *appendix vermiformis* is a narrow, slender tube, about the size of a goose quill, five inches long, and is given off from the cæcum, just below the ileum. It is loosely connected with the exterior of that intestine by a process of peritoneum. It is composed of coats, similar to the intestines: its mucous coat extends from the interior of the cæcum, has numerous follicular appendages, and is generally found full of mucus. Its particular use in the animal economy is wholly unknown. In the fœtus, it is comparatively larger than in the adult.

In an anatomical point of view, the *colon* has but little interest beyond what we have already described in its relative position; for which *vide page* 41. The organization of the colon is similar to that of the cæcum; and may be distinguished readily from the small intestines by its three longitudinal bands of muscular fibres, by its sacculated appearance, and by its appendices epiploicæ. It is smaller than the cæcum, and not much larger than the small intestines, but usually presents a larger appearance from distention by air,—a very common occurrence found in *post mortem* examinations. The *arteries* of the cæcum and

colon, as far as the sigmoid flexion, are derived from the concavity of the superior mesenteric.

The *organization of the rectum.*—Considerable variety will be found in the structure of this intestine, from the office it has to perform in the function of defecation. Its outer or peritoneal coat surrounds only the upper third of the intestine, forming in that situation, the meso-rectum; in its middle third, the anterior surface only receives a peritoneal covering; while the lower third is destitute of the peritoneum. From the anterior surface of the middle third, the peritoneum is reflected from the bladder, in the male; and from the uterus, in the female: from distention of these organs, the peritoneum is raised from this portion of the intestine.

The *muscular* coat of the rectum is thicker than that of the other intestines, and the arrangement of its fibres presents a considerable difference. The external or longitudinal fibres gradually lose their distinct arrangement, in bands which are not to be traced beyond the two upper thirds. In the lower third the circular fibres predominate, and are of a redder color, and thicker as they approach the anus; where, completely surrounding the organ, they have been described by some anatomists as an inner sphincter.

The *mucous* membrane of the rectum is similar to that of the rest of the alimentary canal, having rugæ, follicles, and villosities; it has no valvulæ conniventes; but the mucous membrane is thrown into longitudinal wrinkles or columns, from ten to twelve in number, between which are several semilunar folds, presenting the appearance of laminæ. The openings of the follicles are also distinct and stand out, secreting a thick white mucus, which constantly lubricates the interior of the intestine. Immediately above the sphincter of the anus the rectum is much dilated, and is surrounded by a quantity of cellular membrane, destitute of adeps, admitting of considerable distention under the accumulation of the fæces, until a convenient opportunity offers for its expulsion.

The *arteries* of the rectum are very numerous, and its principal branehes are derived from the inferior mesenteric above, from the internal iliac in the middle, and from the internal pudic below; these constitute the hæmorrhoidal vessels.

The *veins* eorrespond to the branches of the arteries; they are large, form numerous communications, and are subjeet to great distention, producing the disease termed hæmorrhoids.

Its *nerves* are derived from two sourees: from the lumbar plexus, whence its voluntary power; and from the hypogastrie plexus, which maintains its involuntary peristaltic aetion.

The *absorbents* of the reetum terminate in the lumbar and hypogastric ganglia, and in a few absorbent glands placed between the layers of the meso-reetum.

Function of Digestion.

Having now considered the relative position and intimate structure of the alimentary canal, and its assistant ehylo-poetic viscera, we shall now proceed to the consideration of the important function of digestion these various structures are destined to perform.

The eonstant neeessity of a supply of food for the support of animal life, is experienced in the sensations of hunger and thirst. The more immediate cause of these sensations, has not been clearly ascertained: they have been referred to the stimuli of eertain seeretions acting upon the eoats of the stomaeh, mouth, and fauees; to the craving which habit creates when it remains ungratified; and to a certain nervous influence resident in the mucous membranes themselves. Whatever the cause may be, it instinetively leads us to seek both solid and liquid food. The food of man, is both animal and vegetable; which he submits to the sense of taste, particularly resident in the tongue and mouth; and which affords him pleasure or disgust, aecording as it is agreeably or disagreeably acted upon by its peculiar quality. The proeess

of digestion is one of the most important, as well as complicated, of all the animal functions. It is a function common to all animals; by which substances extraneous to them are introduced into their bodies, and subjected to the action of a peculiar system of organs,—their qualities altered, and new compounds formed, fitted to their nourishment and growth.

Great attention has been paid to every phenomenon attendant upon digestion, without, however, unveiling the mystery concealed in this wonderful result of vitality. In order to elicit truth, it is certainly necessary to remark minutiæ, but this may be carried too far; as, for instance, by those physiologists who commence the history of this process with the movements of the upper extremity, in order to introduce portions of food into the mouth; and again, that the mouth must be opened to receive it. I shall, however, content myself by considering digestion under the heads of mastication, deglutition, chymification, chylification, excrementition, and expulsion or defecation.

Mastication.

The first process of digestion consists in the mastication, or grinding down of the food by the motions of the lower jaw, and its mixture with the saliva abundantly secreted by glands, placed for this purpose into the mouth*. At the same time, the masticated mass acquires a certain degree of temperature, which is generally equal to that of the blood; while the saliva, by its solvent power, predisposes the food for the future changes it has to undergo. Such substances as are not capable of being dissolved by the saliva, do not appear to excite the sense of taste, and probably are not capable of being assimilated.

This first process has been termed insalivation, as well as mastication; but their simultaneous actions are, in fact, but parts of one process.

* The minute structure of the salivary apparatus will be given when speaking of the sense of taste.

The saliva is a clear limpid viscid fluid, without taste or smell; its specific gravity is 1·0038; and from the quantity in which it is secreted, it necessarily performs a most important office in the process of digestion.

According to Berzelius, it consists of—

Water	992 ·9
Peculiar animal matter	2 ·9
Mucus—albumen of Bostock .	1 ·4
Alkaline muriates	1 ·7
Lactate of soda and animal matter	0 ·9
Pure soda	0 ·2
	1000 ·0

It has a strong affinity for oxygen, and froths upon being mixed with it, absorbing it readily from the air, and as readily parting with it to other bodies; hence gold or silver may be oxydized when triturated with it; trituration is necessary to mix it with water.

It is not improbable, as remarked by Richerand, that azote may be absorbed, as well as oxygen, during the process of mastication, for the purposes of the animal economy. The saliva may be much altered by disease, as may be seen in the deranged digestion in consequence of the influence of mercury. In a case of obstinate venereal, oxalic acid has been detected in this fluid.

Deglutition.

The process of mastication being completed, deglutition is the next function to be performed. The first step of which, is produced by the tongue collecting the masticated food in the form of a bolus, which this organ, by the various actions of its muscular fibres, throws backwards upon the uvula; and immediately the muscles of the fauces and soft palate are put in action, the anterior and posterior pillars of the fauces press the food backwards towards the pharynx; while the soft palate, becoming raised and strait-

ened, prevents the food from passing either into the nostrils, or the eustachian tubes; and is therefore, by the elevation of the tongue, and still continued action of the pillars of the fauces, pressed backwards into the pharynx. During this muscular action, in consequence of the posterior pillars of the fauces being fixed to the thyroid cartilage, the larynx and pharynx are necessarily raised; by the former, the glottis is closed, the epiglottis being pressed against the tongue; while by the latter, the elevation of the pharynx places it in the best possible situation to receive the food, which is lubricated by the mucus belonging to these parts, as well as by the secretion pressed from the tonsils, by the action of the pillars of the fauces. When the mass arrives on the upper constrictor of the pharynx, that muscle contracts, pressing it downwards to the middle constrictor, which, in a similar manner, delivers it to the inferior constrictor; it then enters the œsophagus, which, by its longitudinal fibres shortening the organ, and the circular fibres contracting on the food, a vermicular motion is produced, conveying the masticated mass into the stomach. During its passage along the pharynx and œsophagus, it is further lubricated by the mucus from those surfaces.

Chymification.

As the food accumulates within the stomach, it is submitted to the action of the gastric juice, a fluid secreted by the mucous membrane; the result of which, is the change of the masticated mass into a homogeneous pulpy substance, called chyme. This process, from certain osbervations on living animals, appears to be effected in the following manner:—The food received into the cardiac extremity of the stomach, is principally there confined by a muscular contraction, about one third from the pyloric extremity; and is moved by a vermicular contraction of the muscular coat, which in some animals appears to give a rotatory movement. The surface of the mass is first changed into chyme; and as it forms, is gradually rolled off

to the pyloric extremity, where it remains until admitted into the duodenum. It appears, that the peristaltic motions of the stomach and intestines commence in the duodenum, gradually extending from thence to the coats of the stomach; then an opposite vermicular motion is set up, at intervals, in the stomach, and is continued over the pylorus to the duodenum, pressing the chyme forward before it.

The chyme thus formed by the action of the gastric juice in the stomach, is of an acidulous flavour: and it is remarkable, that from whatever food it is produced, this is the case. From the experiments of Tiedemann and Gmelin, it was found, that the fluid secreted in the stomach without food, was clear and viscid, and did not contain any perceptible acidity; but immediately the coats of the stomach were stimulated by food, it became acid. *(Ed: Med: Journal.* No. XCIII.*)* The acid thus generated, Dr. Prout found to be muriatic, both free and in combination with alkalies. *(Phil: Trans:* 1824. *p.* 48.*)*

Many theories have been advanced to account for the changes produced upon the food in the stomach,—concoction, fermentation, putrefaction, trituration and maceration, have each had its partisans; while numerous experiments have from time to time been made, without, however, removing that obscurity in which the subject is still involved. The change produced in the masticated food, is not reducible to any of the known laws of chemical or mechanical philosophy. It resembles the action of chemical re-agents, but with this essential difference,—each change produced is modified by its connection with vital influence. Although Spalanzani positively asserts that the gastric juice, assisted by heat, will exert its solvent powers out of the body, it is not with the same energy as when in connection with a vital function, and loses this power after a short space of time: it is however, doubtful, whether or not these artificial digestions, as they have been called, possess any analogy to chymification; from recent experiments by M. T. Montegre, it appears they have not. Heat has been supposed to be a

necessary auxiliary in digestion. Hunter, however, in his animal economy observes, that heat can only be a remote cause; for digestion goes on equally well in fishes, whose natural temperature seldom exceeds 50°, as in man, whose heat is 98°. The process is suspended in torpid animals at the temperature of 30°.

A great variety of experiments have also been made, by submitting different substances to the action of the gastric juice, in order to ascertain the changes produced. The result appears to amount to this:—that the general action of chymification consists in converting the substances submitted to the action of the stomach, more or less, to the nature of albumen. Every animal substance undergoes this remarkable change, excepting albumen, which remains unaltered when submitted to the action of the gastric juice. Albumen will pass the pylorus more rapidly than any other aliment.

Fluids appear to be acted upon by being absorbed or imbibed. M. Magendie tied the pylorus in a living animal, and found the absorption of fluids little if at all impeded. The same occurs with various medicinal substances. This subject is also involved in considerable mystery; for dissection has not yet enabled us to prove that the absorbents form the direct route of the fluids from the stomach to the kidneys; while it has been conjectured, that some short course exists, from the great readiness of their passage from one organ to the other.

No material fact has ever been elicited from the experiments relative to nervous influence. Division of the pneumo-gastric nerves merely retards the process of chymification; in the same manner as narcotics, administered so as to produce coma, or injuries of the brain affect the stomach by diminishing the amount of nervous influence transmitted to it. It has been ascertained, however, that after the division of the *par vagum*, chymification is retarded; and that the chyme itself when formed, is destitute of its natural acid qualities, and is become alkaline: but if the truncated

nerve be made the medium of a galvanic influence, the acid qualities will be produced.

The gastric juice is neither acid nor alkaline; it possesses a peculiar solvent power, combining with the food taken into the stomach so intimately, as to change its nature. It is antiseptic, suspending the putrefaction of animal substances, whence it has been used with success as an application to foul ulcers. Its solvent power is not equally active on all substances; in some its action is resisted, as by the parietes of the living stomach, vermes, stones of fruit, seeds, &c. Its composition resembles the saliva, but from the difficulty in obtaining it pure, very little is known of its analysis. Magendie relates an analysis by M. Chevreul thus: —"Much water, considerable mucus, some lactic acid combined with animal matter soluble in water, and insoluble in alcohol; a little hydrochlorate of ammonia, and hydrochlorate of potass, and a certain quantity of hydrochlorate of soda." —*Vide* Milligan's translation of "Magendie's Elements of Physiology;" p. 168. Such a vague analysis is scarcely worth mentioning, excepting to shew how little is known respecting it.

Chyme has been frequently analyzed; but there is every reason to suppose, that its nature varies with the quality, and quantity of food, as well as the state of health of the individual: from whence the results are extremely uncertain.

Chyme formed from vegetable and animal food, has been analyzed by Dr. Prout, and affords the following results:—

Vegetable Food.		*Animal Food.*	
Water	88 · 5	Water	80 · 0
Chyme, &c. . .	6 · 0	Chyme, &c. . . .	15 · 8
Biliary principle .	1 · 6	Albuminous matter	1 · 3
Vegetable gluten .	5 · 0	Biliary principle .	1 · 7
Saline matter . .	0 · 7	Saline matters . .	0 · 7
Insoluble residuum	0 · 2	Insoluble residuum	0 · 5
	100 · 0		100 · 0

The time which a meal takes to be converted into chyme, is supposed to be about four hours; but this varies according to the nature of the food.

While digestion is going on, the openings of the stomach are closed against the regurgitation of the food into the pylorus; the escape of gas is owing to imperfect digestion. In many, a slight shivering is felt, the pulse is quickened; and in delicate women, the insensible perspiration is increased, so as to resemble a paroxysm of fever. The food is submitted to the action of the gastric juices by continued muscular movements; it does not, however, leave the stomach in the same order as it enters. The pylorus has a delicate sensibility, and closes against such portions of food as are not in a fit state to pass; and it possesses a sort of discriminating faculty, whence its name: thus, a substance not capable of being acted upon by the gastric juice, it allows to pass with the more perfectly chymified food; and should this be of a nature to injure the coats of the intestines, it will be covered with thick mucus to guard it from any asperity of surface which might occasion injury. From experiments tried upon living animals it has been found, also, that substances capable of further chymification having passed into the duodenum, will be forced back again into the stomach to be submitted to its further action.

Various causes will retard the process of digestion; among which, are imperfect mastication, sedentary habit, violent mental emotions, violent exercises immediately after eating, the recumbent position on the left side, and improper food: on the contrary, gentle exercise appears to promote the process, particularly in the process of the aliment through the intestines. Ease, and cheerfulness of mind, also promote digestion; as well as the general healthy actions of the whole system.

At times the stomach rejects its contents, by a convulsive action called vomiting; in this, the peristaltic motions are inverted, the muscles of the abdomen are excited by a spasmodic sympathy; they then contract, forcing the viscera

upwards and backwards,—the diaphragm rising into the thorax: the pressure thus produced on the organ forces its contents into the œsophagus,—the pylorus at the same time offering a corresponding resistance.

Vomiting may arise from disease of the stomach itself, or from sympathy with other organs, or from sympathy in diseases; as may be seen in the effects of poisons, of injuries to the head, and the commencement of fevers.

Chylification.

The next process of digestion consists in the conversion of chyme into chyle; which process commences in the small intestines, and appears to be the result of the admixture of the bile, pancreatic juice, and mucous secretions with the chyme in the duodenum. This change is equally if not more essential than that produced in the stomach, which in some measure is subservient though previous to it. It is in the duodenum that the food is first separated into two ultimate formations, namely, nutritious and excrementitious substances: for which important purpose, every thing tends to retard the progress of the food in the duodenum,—its curvatures, its numerous valves, its extensive power of dilatation, the thickness of its coats (compared with the rest of the small intestines); and the numerous chylous vessels which arise from it.

The ducts of the liver and pancreas open into it; the bile does not flow in a continued stream, but at intervals of about twice in a minute; a drop exudes, which is diffused with the pancreatic juice in the chyme. The effect of this mixture, is shortly to separate the chyme into two portions; the one a whitish, tenacious liquid, termed chyle,—the other a yellow, pulpy, excrementitious matter. The former of these is absorbed by the numerous villi, as it slowly passes along the intestines; while the latter proceeds, undergoing however still farther changes before it reaches the rectum, from whence it is finally expelled. As the chyle passes along the small intestines, it gradually looses its acid quali-

ties; the albumen also decreasing in quantity from the duodenum downwards.

Before we trace the aliment in its progress along the small and large intestines, and the further change it is in that progress destined to undergo, it will be necessary to take a particular view of the secretions which have been added to it by the liver and pancreas.

Of the *bile,* and its uses as an agent in the process of chylification, various conflicting opinions are entertained; the following appears to be most worthy of notice. As the liver, in all red-blooded animals, is placed so as to discharge its secretions, at the commencement of the small intestines, and before the separation of the nutritious from the excrementitious part of the aliment; it is presumed, that a principal object of the bile is, to effect the change of chyle into chyme. It has also, no doubt, other very important purposes to perform.

When the ductus communis choledochus has been tied in a dog, the thoracic duct will still be found filled with fluid, differing from chyle only in color; at the same time, the fæces are found white in color, of a peculiarly fœtid odour, with a high degree of putrescency. Hence it has been concluded, that the bile has a tendency to prevent the putrefaction of the food during its course through the intestines; and that it further excites the flow of the follicular secretions, by which the fæces are prevented from acquiring too dry a state. This latter property has been deduced from the observation, that the fæces of jaundiced persons are invariably in a dry hardened state.

The various substances contained in the bile, consisting as they do of such highly azotised principles, it is not improbable that it contributes to animalize those articles of food which are deficient in the quantity of azote they contain, It has also been observed, that the bile has a peculiar power of decomposing fatty substances; which Professor Tiedemann and Gmelin consider the sole agency

of the bile in chymification. The white color of the chyme depends on the fatty matters dissolved in the food; for when formed from food destitute of fat or oil, the white color does not exist.

The most probable additional office assigned to the secretion of the liver, is that of forming an important excrement from the blood itself. From the experiments of Malphigi and Simon we learn, that all the principles of the bile are thrown out of the system with the excrements; and they observe, that in case of biliary obstructions, they are diffused in the cellular tissue, or escape by the urine. These principles contain a great proportion of carbon, and probably, therefore, tend greatly to decarbonize the blood. In herbivorous animals, whose food abounds in carbon, the resin of the bile is found in abundance. Hence the liver throws off carbon by uniting it to hydrogen, forming resin; while, in the lungs, it is thrown out in union with oxygen. Thus it is found that, in various animals, the size of the liver and the quantity of the bile is not in proportion to the quantity of food eaten, but in proportion to the size and perfection of the lungs: and what is still more to the point, more venous blood is sent through the livers of those animals which have small or imperfect lungs. Thus in birds and fishes, the vena portæ receive, in addition, the renal veins, and those of the genital organs; in serpents, those also from the intercostal veins. In the fœtus, the liver is much larger in proportion to that of the adult, and is much more abundant in its secretion of bile; which is seen in the frequent occurrence of jaundice at birth, and the quantity of bile found in the meconium in the latter months of gestation.

This office is further established by a multitude of pathological facts. In pneumonia and phthysis, the liver is frequently superabundant in its secretion of bile; in the morbus ceruleus, it retains its fœtal proportions; in diseases of the heart, the liver is enlarged; in hot climates

it is also enlarged, owing to the abundant call upon its particular office from the great rarefaction of the air, which tends to lessen the perfection of the function of the lungs.

Finally, during the hybernation of certain mammalia, when respiration is suspended, and no food is taken in, the secretion of bile goes on.

Human bile differs from that of all other animals. Its color varies from a green, to a yellowish brown; and sometimes it is nearly in a colorless state. All the acids decompose human bile, precipitating albumen and resin copiously.

The appearance of the bile is different when taken from the gall bladder, in which it is always bitter, pungent, and viscid, from what it is when taken from the hepatic duct, during chylification. It then passes directly from the liver to the intestines, and is bland and harmless. Hence it has been supposed, that the ductus cysticus acts as an absorbent, selecting the more active principles of the bile to be detained in the gall bladder until required in the process of digestion; where it acts as a gentle purge, stimulating the follicular and other secretions.

Berzelius gives the following analysis:—

Water	908 ·4
Picromel	80 ·0
Albumen	3 ·0
Soda	4 ·1
Phosphate of lime	0 ·1
Common salt	3 ·4
Phosphate of soda, with some lime	1 ·0
	1000 ·0

According to the French chymists, the constituents of bile

are mucus, albumen, ozmazome, gliadine, casein, picromel, asparagin, acetic acid, oleic acid, margaric acid, cholic acid, resin, and coloring matter; but some of these, I question, with Brande, whether they are to be considered as products or educts. It may be said of the bile, that it is at once watery, albuminous, oily, alkaline, and saline.

We may, therefore, conclude, from these considerations, as well as from the fact, that bile poured upon chyme, out of the body, will effect the separation of the chyle from the chyme, that the secretion of the liver is not only essential to complete chylification, but it performs an important excretion from the blood itself, by abstracting carbon; and that it further prevents too great a putrefactive process in the excrement, and stimulates the intestines to induce the passage of their contents.

Of the *pancreatic juice,* which flows into the duodenum with the bile, very little is known, more than its general resemblance to saliva. Tiedemann and Gmelin state that the pancreatic fluid contains a large proportion of highly azotised principles, namely, albumen, casein, ozmazome, and a matter which is turned red by chlorine. Besides the bile and pancreatic juices, a quantity of mucus is secreted in the duodenum, which mixes with the aliment, and is subservient to the healthy process of digestion.

Excrementition.

The food in its passage along the small intestines continues to impart its nutritious particles, in the form of chyle, to the absorbents or lacteals, whose open mouths are every where numerously dispersed on the villi of the valvulæ conniventes, which for this purpose retard the progress of the aliment passing between their folds. The peristaltic action of the intestines promotes the passage of the food, in conjunction with an abundant mucous secretion, chiefly of an excrementitious nature, which lubricates the passing substances; this peristaltic action does not continue in a regular succession

from the stomach to the cæcum, but shews itself at several points at once, and is probably excited by the stimulating qualities of the aliment.

Having traced the progress of the aliment through the small intestines, and considered the properties of the several secretions added to it in its course, we have now to consider its further progress through the large intestines. When the aliment obtains an entrance into the cæcum, it is called excremental or fæcal; at this point the fæcal matter has lost its acid qualities, but acquires acidity again in the large intestines.

The situation and peculiar structure of the cæcum, its great capacity, and the slow motion of the aliments, having to ascend contrary to their gravity, have induced a belief that in this viscus a new process of digestion is set up, analogous to that performed in the stomach, for the purpose of extracting those portions of nutrition which have not been separated in the stomach and small intestines; for this purpose Tiedemann and Gmelin consider the large follicles in the cæcum are destined, and that they secrete an albuminous, acid, solvent fluid, which, in like manner to the gastric juice, mixes intimately with the aliments poured in from the ileum; certain it is, that nourishment is obtained from substances thrown in by injection, but it has not been ascertained how far injections per anum reach along the bowels.

In the cæcum the first process of fæcation commences, and the excrement begins to assume its peculiar feculent odour: this odour is supposed to be derived from a volatile oil secreted in the cæcum; an hydro sulphurated gas is also separated,—more abundantly in debilitated persons, and under circumstances of disease.

The fæcal mass is composed of the residue of the aliments and of the excrementitious parts of the secretions of the digestive canal.

Berzelius gives the following analysis :—

Water	73 ·3
Vegetable and animal remains .	7 ·0
Bile	0 ·9
Albumen	0 ·9
Peculiar extractive matter . .	2 ·7
Slimy matter, consisting of picromel, peculiar animal matter, and insoluble residue . . .	14 ·0
Salts	1 ·2
	100 ·0

Expulsion.

As the excrementitious mass reaches the rectum it continues to increase in hardness, and to acquire a peculiar fetor. In the rectum its presence proves a stimulus to the muscular fibres of the part, in which all the muscles of the abdomen more or less participate; hence arises that desire, and the consequent efforts, which finally effect the act of expulsion.

In the examination of the contents of the stomach and the intestinal canal, we have yet to mention the different gases which are generally met with; the principal difference consists in the presence of oxygen in the stomach, and which probably is absorbed and conveyed into the circulation before it reaches the intestinal canal.

The gases found in four executed criminals, examined in Paris, were as follow :—

In the stomach—oxygen, carbonic acid, hydrogen, and azote.

In the small intestines—carbonic acid, hydrogen, and azote.

In the large intestines—carbonic acid, hydrogen, carburetted hydrogen, and azote.

In the rectum—carbonic acid, carburetted hydrogen, and azote.

LECTURE XXIV.

OF THE ABDOMEN AND ITS CONTENTS.

The second class of organs contained within the cavity of the abdomen, are those which perform the function of the secretion and excretion of urine: they consist of the capsulæ renales, kidneys, ureters, bladder, and urethra.

The *capsulæ renales*, are two small bodies, having the appearance of glands, placed within the lumbar region of the abdomen, behind the peritoneum, above the kidneys, of which they embrace the superior and inner extremities.

They are held in their situation by a quantity of cellular membrane, containing adeps and numerous vessels, which are most obvious between the kidneys, and the renal capsules at their upper part.

The capsulæ renales present an irregular triangular figure, their broader surface being directed towards the kidney; they are of a brownish yellow color externally, and of a deep red brown internally, in the adult; but in the fœtus, are more inclined to a red.

The anterior surfaces of the capsulæ renales, are differently bounded on the right and left side. On the *right* side, by the duodenum, liver, and the ascending cava; on the *left* side, by the spleen and pancreas. Both of them *above*, are bounded by the diaphragm, and that on the right side, by the liver; *below*, by the kidneys; and *behind*, by the psoæ muscles, on which they rest. The left capsula renalis is rather higher than the right, corresponding with the position of the kidney, and is placed upon a level with the eleventh dorsal vertebra.

Each capsula renalis contains a cavity, in form somewhat

corresponding to its exterior walls, is therefore of a triangular shape, and has a slightly elevated ridge or crest upon its lower surface. It contains a viscid, albuminous secretion, abundant in the fœtus, and of a yellow color; in adults and old people it is less abundant, and of a brown color. The substance of this organ presents a granulated or lobular appearance in the fœtus, which appearance becomes less perceptible at the adult period. Its structure is composed of numerous vessels, united by a strong cellular tissue, which is more dense towards the exterior than in the interior substance of the organ. Some anatomists have described the capsulæ renales as being made of a parenchyma composed of minute lobes, divisible into minuter lobules; but upon further inspection, it will be found that these apparent lobules may be unravelled, displaying a series of blood-vessels, the larger of which are the veins, connected by cellular membrane. Meckel denies that there is any internal cavity to this organ, and asserts that manipulation and spontaneous decomposition is the sole cause of this appearance. If however, the veins are injected, or even cut open as they enter the capsule, they will be found to enlarge, forming one principal cavity, which seems to have been mistaken for a closed bag within the organ.

The *arteries* are numerous, and are derived principally from three sources: *above,* from the diaphragmatic; *below,* from the emulgent; and in the *middle,* from the aorta. They ramify on the surface of the gland, and enter its substance by a multitude of minutely divided branches.

The *veins,* on the contrary, leave the organ in one or two large branches, more in the manner of a duct from its interior than as veins accompanying ordinary arterial distribution. This arrangement of vessels would lead one to suppose the vein is the true excretory duct, and that the capsulæ renales perform some office of assimilation to the blood immediately connected with the eliminating function of the kidneys. In the fœtus, these organs nearly equal the kidneys in size; and it is worthy of remark, also, that if they

perform any office of assimilation to the blood, that their principal veins unite with the veins of the kidneys immediately after their exit from those organs, and together join the general circulation. In the fœtus the veins of the capsulæ renales are at least two-thirds the size of the ascending cava.

Their *nerves* are derived from the renal plexus.

Their *absorbents* terminate in the emulgent, and inferior diaphragmatic ganglia.

The Kidneys

Are complicated glands, being composed partly of structures which secrete, and partly of structures which excrete the urine.

They are situated in the posterior part of each lumbar region, lying on the diaphragm, psoas, and quadratus lumborum muscles; corresponding, in the direction of their long axis, to a space between the tenth dorsal and third lumbar vertebræ. They are situated behind the peritoneum, which adheres to them by loose cellular membrane; the right kidney is rather lower than the left, in consequence of the great size of the right lobe of the liver. Their figure is irregularly oval, presenting an anterior and posterior surface, a superior and an inferior extremity, an external and an internal edge. The *anterior surface* is convex, and covered entirely by peritoneum. The *posterior surface* is less convex than the anterior, is embedded in adeps, and has little or no covering from the peritoneum. The *superior extremity* is larger than the *inferior*, and is rather more inclined inwards towards the mesian line. The *external edge* is convex, and is directed outwards, and slightly backwards. The *internal edge* is formed by the rounded extremities turning inwards, leaving between them a fissure for the passage of the vessels and excretory duct of the gland; the fissure is of various depths in different subjects, and is more perceptible on the anterior than the posterior surface, in consequence of a projection of the substance of the gland

which lies under the vessels. Considerable varieties exist in the form of the kidneys in different individuals, both in the fœtal and adult periods. In some subjects, they are united by a continuation of glandular structure passing across the spine from one kidney to the other; in others, they have been found three in number; and again, a single gland placed transversely on the spine. The volume of the kidneys generally, relatively to each other, as well as the number of their vessels, are subject to a similar extensive variety.

In the fœtus the kidney presents a lobulated appearance, being deeply indented between the lobes; but this is generally lost in the adult period, excepting close to the fissure, where they always remain more or less obvious.

Physiologists describe the kidneys to be comparatively large in the fœtus, smallest in old age, and intermediate in the adult.

Organization of the Kidney.—Besides the partial peritoneal covering, which is but loosely connected, the kidney has a cellular adipose capsule, and a proper strong fibrous tunic. The adipose capsule is thicker and most abundant on the posterior and external edge of the kidney.

The *proper fibrous tunic,* invests the whole external surface of the kidney, and dips into the fissure, accompanying the vessels, reaching as far as the infundibula, from whence it is reflected upon the external surface of its pelvis.

Before removing the kidneys to observe their minute structure, the relative position of their vessels should be examined.

The *artery* to each kidney is derived from the aorta; that of the right side is longer than on the left, and crosses behind the vena cava. The renal arteries in their course to the kidneys are placed between, their corresponding veins, which are in front of them, and the ureters, which are behind and below them.

The *veins* pass from the kidneys to terminate in the vena cava; that on the left side, which is the longest, crossing in front of the aorta.

The *excretory duct* or ureter, passes from the fissure behind and below both the artery and the vein, and makes an immediate turn downwards towards the bladder, as will be hereafter described in its connection with that organ.

The internal structure or substance of the kidney, is made up of two parts; one called the *cortical*, and the other the *mammillary* or tubular. The cortical is the most external, and is to be considered as the secreting portion of the organ, while the mammillary consists of the excretory apparatus.

The minute examination of the structure of the kidneys presents the same difficulty that is met with in that of other glandular organs: their arteries, veins, and excretories, are so infinitely minute, that the actual termination of the arteries and commencement of the veins and ducts is but little understood.

The *cortical* part forms the periphery of the kidney, and extends into its substance to the depth of two or three lines, sending septa or prolongations between the conical bundles of the tubular substance: its color is a brown red, and seems to be made up of the ultimate and tortuous ramifications of the arteries and veins. According to the microscopical observations of Dr. Eysenhardt, of Berlin, this structure is made up of minute granules, of oval and rounded forms; these by maceration become detached with their adherent vessels, and are rendered completely red by fine injection thrown in by the artery; they appear to be composed of minute plexus of vessels, surrounded by a grey colored substance, which is not granular. The veins could not be detected arising from them; this probably occurred from the veins being injected from the arteries, as I have myself injected the veins of the kidney in that manner.

The granules of the cortical part are held together by a minute net-work of greyish transparent vessels, which seem to be the commencement of the uriniferous tubes; this would throw doubt on the assertion, that each granule is furnished with its own excretory duct, running in a straight line to the tubular substance. Further than this the con-

nection between the blood-vessels and glandular structure of the kidneys is little known.

The *tubular* substance appears to arise or be a continuation of the grey substance, which has been already described as connecting the granules of the cortical part; they unite into conical bundles, from twelve to eighteen in number; their bases are directed towards the circumference of the kidney, and their summits towards the pelvis and fissure. These cones are whiter in color than the cortical substance, particularly where they concentrate at their apices and form the mammillary processes. Each of these cones contains several tubuli uriniferi, which converge as they pass towards the mammillary process of the cone, uniting with each other, and finally opening by only two or three apertures into a calyx or infundibulum.

The *calices* or *infundibula,* form the second excretory portion of the internal structure of the kidney, and may be considered as the commencement of the ureter. It is formed of a dense fibrous tissue, surrounding the mammillary processes; and uniting with each other, form one common cavity around the pelvis, from whence the ureter takes its origin at the fissure of the kidney: but each mammillary process is not always furnished with a separate infundibulum, as sometimes two, or even three will open into one infundibulum. The fibrous tissue of the infundibula and pelvis is strengthened by the intimate connection of the proper fibrous tunic of the kidney.

The *function of the kidneys.*—The secretion of the urine appears to be wholly excrementitious, which is fully proved by an examination of the various constituents of the urine, under the different circumstances of health and disease. The principal excrementitious constituent of urine is in the form of the substance named urea or nephrin, and which is found in healthy urine, according to Berzelius, in the proportion of rather more than thirty parts in a thousand. The principal constituent of urea has been stated by Dr. Prout to consist of azote in the proportion of nearly one half;

hence the conclusion of Dr. Elliotson, that the kidneys are the great outlet for azote, as the lungs and liver are for carbon.

When the kidneys have been removed from animals, urine has been detected in the blood, and stated by Segalas in the proportion of one scruple to five ounces; he also found, that when an aqueous solution of urea was injected into the veins, it acted as a most powerful diuretic, so that in twenty-four hours it could no longer be detected in the blood. These facts seem to point out, that urea is not necessarily formed in the kidneys, as was formerly supposed, but that it is merely eliminated by these glands from the blood, which is furnished with this substance from all the other parts of the system. This must necessarily be the case, if the azote of the urea is furnished from the different textures of the body, during the process of their absorption, when being carried into the circulation, without some outlet the azote of their composition would form an injurious accumulation.

The urine is an extremely complex fluid, as may be seen from the following analysis of Berzelius, which presents the characters of healthy urine; but under different states of disease, its constituents will be infinitely varied, which renders the analysis extremely difficult.

Water	933 · 00
Urea	30 · 10
Sulphate of potassa	3 · 71
Sulphate of soda	3 · 16
Phosphate of soda	2 · 94
Muriate of soda	4 · 45
Phosphate of ammonia	1 · 65
Muriate of ammonia	1 · 50
Free lactic acid Lactate of ammonia Animal matter soluble in alcohol Urea not separable from the preceding	17 · 14

Earthy phosphates, with a trace of fluate of lime	1 · 00
Uric acid	1 · 00
Mucus of the bladder	0 · 32
Silica	0 · 03
	1000 · 00

According to the analysis of Brande, the following constituents are always found in the urine :—

Water.	
Carbonic acid	Three free acids.
Phosphoric acid	
Uric acid	
Phosphate of lime	Two earthy phosphates.
Phosphate of magnesia	
Phosphate of ammonia	Two alkaline phosphates.
Phosphate of soda	
Muriate of soda	Chloride.
Albumen	Two animal compounds.
Urea	

and a trace of sulphate of soda.

Urea is soluble in water and in alcohol; it is precipitated by nitric and oxalic acid in crystals of a pearly hue; soda and potassa dissolve it.

Dr. Prout gives the following analysis of the ultimate elements of urea :—

Nitrogen	46 · 66
Carbon	19 · 99
Hydrogen	6 · 66
Oxygen	26 · 66
	99 · 97

These different substances found in the urine form a corroboration of the view taken of the excrementitious function

of the kidneys, and which is rendered still more apparent from the alterations produced in its secretion by various diseases. Thus, in certain cases of rickets, the urine will be found saturated with phosphate of lime. When the functions of the liver are interrupted, the urine is often found loaded with bile, as is evident in jaundice, when the bile is generally diffused through the system. In typhus fever, gelatine and urea are abundantly contained in the urine. In intermittent fevers, the color of the urine varies with the paroxysm. Dr. Prout found a peculiar red deposit in urine after a fit of ague, containing an acid which, from its color, he has named rosacic acid. In gout, lithic acid is deposited in red crystals. In inflammatory fevers, the urine is red or dark colored at first; as the disease lessens it becomes turbid, and deposits a sediment of a reddish color, containing phosphate of lime, lithic acid, lithate of ammonia, and animal matter.

Uric acid appears to be peculiar to human urine, and to be formed by the union of urea with a small proportion of oxygen; it differs from urea in its strong tendency to crystalize upon any reduction of the natural temperature of the body: hence the ready formation of calculi in the human bladder, and the frequent turbid state of the urine. Quadrupeds, on the contrary, from the absence of uric acid in their urine, are rarely the subjects of urinary calculi; and those which do form are found to be composed of carbonate of lime, which being easily dissolved by the weak acids of the urine, do rarely concrete.

The secretion and course of urine take place from the ultimate distribution of the renal arteries, which have already been described as ramifying on the granules of the cortical substance of the kidney, from whence the commencement of the tubuli uriniferi have been traced; into these tubes the urine is poured, and is conveyed by them through the open mouths of the mammillary processes into the infundibula; from thence falling into the pelvis of the kidneys, it flows through the ureter into the bladder. Several opinions have

been entertained respecting the force and mode by which the urine is propelled in this passage: some physiologists have considered that the ureters possess a muscular power; others attribute it to the general motion of the peristaltic action of the intestines, and contraction of the abdominal muscles; while others consider, these passages being always full of urine, each additional secretion must necessarily, from the incompressibility of fluid, displace an equal quantity from the opposite extremity of the tube into the bladder. This hypothesis is supported by the fact, that in experiments upon animals, and in cases of malformation of the anterior parietes of the abdomen, and anterior surface of the bladder, the urine is seen invariably flowing guttatim from the ureter.

The remarkable facility with which fluids find their way from the stomach to the bladder, has given rise to a supposition, that the absorbents have a direct communication between them, independent of the kidneys. Anatomy, however, does not verify these conjectures; although, occasionally, absorbent vessels much enlarged may be traced, but never, I believe, in distinct continuation.

One of the most remarkable phenomena attending the secretion of urine is, that certain substances taken into the stomach may be detected in the urine before they can be detected in the blood. Rhubarb, when taken into the stomach, was detected in the urine in seventeen minutes, by Sir Everard Home; and if doses are successively administered to animals for several hours before they are killed, not only the urine contains it, but it is also found in the splenic vein, vena cava inferior, and right auricle of the heart. Rhubarb may be detected in the bile, and in the urine, when it cannot be discovered in the lacteals. (*Vide* Exp: Sir Everard Home, Phil: Trans: Vol. CI. page 163.) The only way of accounting for this phenomenon is, that the blood possesses a power of preventing the usual operation of chemical tests: this fact was ascertained by Magendie; he injected prussiate of potash into the veins, and found that it might be detected in the urine, but not in the blood; and

this power it also possessed when tried out of the body: chemical tests being unaffected when applied to solutions of prussiates of potash in the blood, while in the urine the slightest quantities were readily detected.

The average quantity of urine secreted in twenty-four hours is about four pints, but this varies greatly. In cold weather, when the skin is less active, its quantity is greatest; on the contrary, in warm weather, when there is an abundant perspiration, the quantity of urine is lessened, and its color heightened. It also varies considerably during the progress of febrile and other diseases; certain medicines, and particular kinds of food increase the secretion of the kidneys—hence the term diuretics. Several substances possess the power of impregnating the urine with particular odours; thus turpentine imparts to it the smell of violets, asparagus a peculiar fætor.

With regard to the facility of the secretion, and the quantity of urine formed, it may be observed, that the size of the renal arteries being in the proportion of an eighth of the calibre of the aorta, admits, by calculation, the passage of one thousand ounces of blood in an hour; and supposing that the blood contained only one tenth of the elements of urine, seven pounds and a quarter may be given out in this time,—which is more than is known to form, even under the influence of the most powerful diuretics.

The ureters descend from the kidneys along the lumbar regions, and pass over the margin of the pelvis to gain the inferior region of the bladder, into which they finally enter. Their mode of junction will be more particularly described when treating of the structure of the bladder, which is postponed until speaking of the organs of generation, their connection with the bladder being so intimate and important as to render their connected description essential.

The Organs of Generation.

The third class of organs contained within the cavity of the abdomen, are the organs of generation, which form the

grand distinction between the male and the female, presenting an extensive variety of structure in the two sexes. We shall first speak of them in the male.

The organs of generation in the male, are composed of numerous parts, presenting a variety in their situation, and in the different functions they are destined to perform. They are therefore divided into the *external* and *internal.*

The external are, the scrotum enclosing the testicles, with a portion of the spermatic cord, and the penis.

The internal are, the remaining portion of the spermatic cord, the vesiculæ seminales, prostate gland, and commencement of the urethra.

The order which I shall adopt in the description of these various structures, is that which will be found most convenient to the anatomical student in the progress of his dissection, as well as that which is best adapted to the important surgical and physiological considerations of these parts.

The *scrotum,* is a pendulous sac or bag, composed of different structures, and divided into two cavities by a septum; each cavity containing one of the testicles. This pendulous bag is attached by its external or cuticular covering to the pubes, *above; laterally,* to the thighs; in *front,* to the penis; and *behind,* to the perineum; being free in the rest of its surface, and hanging down to a greater or less extent, depending on the age, vigor, and general state of health of the individual. It is particularly contracted by cold, and by a vigorous state of constitution; on the contrary, it is loose and elongated in states of debility.

The external covering of the scrotum, is a continuation from the common integument, its general organization being the same; it is however peculiar for its brown color, the quantity of sebaceous follicles which it contains, and the numerous hairs scattered over its surface in the adult. In its different states of contraction or elongation, it presents more or less of a rugous appearance, and it has a raphé in its centre, extending from its junction with the posterior part

of the penis to the anterior part of the perineum; which raphé is a continuation of the mesian line of the body. The skin of the scrotum is extremely thin and transparent, and is connected to the subjacent parts by cellular membrane destitute of adeps.

The *dartos* is the covering next immediately under the skin, and has been supposed by many to possess a muscular structure, to which they have attributed the corrugation of the scrotum; by minute examination, however, no muscular fibres can be discovered, but it appears a pinkish cellular tissue, containing an extensive vascular distribution. It is connected, laterally, with the rami of the pubes, and ischia; and in the centre, with the raphé, from which it ascends to the urethra, and assists in forming the septum scroti.

The *superficial fascia* of the scrotum is the third covering, and lies immediately underneath the dartos; it is here so named, having been usually considered as a distinct covering; but it is, in fact, so inseparable from the dartos, that they appear to be one and the same. It is a continuation of the superficial fascia of the perineum, proceeding between the dartos and cremaster muscle, surrounds the testicles, assists in forming the septum scroti, and in retaining each testicle in its proper situation; it then passes upwards upon the outer side of the cremaster muscle, and, reaching the external abdominal ring, is continued with the superficial fascia of the abdomen.

The *cremaster muscle*, is the next layer of the scrotum usually described; it takes its rise within the inguinal canal, from the lower fibres of the internal abdominal oblique and transversalis muscles, and thence passes through the external ring, forming at once a covering to the spermatic cord and scrotum. As it passes through the external ring, it does not however lie immediately under the superficial fascia of the scrotum, for there is a thin layer of fibrous tissue proceeding from the edges of the external ring, which passes downwards along the cord, separating the cremaster from the superficial fascia, and may be termed the fascia spermatica externa.

The cremaster muscle is inserted into the tunica vaginalis reflexa, upon which its fibres are gradually lost, but are most abundant on the fore part of the tunica vaginalis. The cremaster is furnished with an artery of its own from the epigastric.

The true covering of the testicle, and which upon the descent of that organ becomes the fifth or inner layer of the scrotum, is the *tunica vaginalis.* This originally was a portion of the serous splanchnic membrane of the abdomen, and invested the testes in the earlier stages of fœtal growth; which having descended with the testes, now forms the tunicæ vaginales. At the earlier period of its descent, a communication remains between the serous cavity of this membrane and the peritoneum of the abdomen; but which soon closes by an adhesive inflammation separating the two cavities from each other. Precisely in the same manner as the peritoneum within the abdomen gives a covering to the viscera and parietes of that cavity, so do the tunicæ vaginales give a covering to the testes, and become reflected upon the scrotum. Hence these tunics present one external surface, closely attached to the organ (excepting only a small portion for the transmission of its vessels), and then is reflected on the internal surface of the scrotum; and another internal free surface, forming a closed serous cavity, smooth, and secreting a fluid similar to the other serous cavities, and facilitates the motions of the testicles. The portion of this tunic which covers the testicle, has been named the tunica vaginalis testis, while the reflected portion has been termed the tunica vaginalis reflexa or seroti.

The farther particulars of the prolongation of the tunicæ vaginales from the peritoneum, will be described when speaking of the descent of the testicle.

From the above description, it would appear that the tunica vaginalis lies immediately under the cremaster muscle, but this is not the case; for precisely in the same manner as the cremaster muscle is separated from the superficial fascia of the scrotum, by the fascia spermatica externa passing

from the edge of the external ring; so is the tunica vaginalis separated from the cremaster by a fascia, which proceeds from the internal ring, and which may be properly named the fascia spermatica interna. Hence it is obvious, that the cremaster muscle is placed between these two fasciæ spermaticæ. *(Vide diagram I.)*

These fasciæ must, necessarily, form coverings in oblique inguinal herniæ, but it would perplex the student to enumerate them as distinct coverings; nor have they been so described by authors, probably in consequence of their extreme tenuity: nevertheless, under circumstances of disease, they may become so thickened as to form an important feature in the operation for strangulated hernia; and should, therefore, be perfectly understood by the surgeon.

The *scrotum* is supplied with blood by the external pudic artery, and the perineal branch of the internal pudic. The cremaster receives a branch from the epigastric.

The *veins* which return the blood from the scrotum, correspond in their course to the arteries; so that there is an external pudic vein conveying blood from the scrotum to the femoral vein, a perineal vein which terminates in the internal pudic, and a vein which opens into the epigastric.

The *nerves* of the scrotum are derived from the lumbar plexus by two branches, and also from the perineal nerve, which is a ramification from the internal pudic.

The *absorbents* terminate in the inguinal glands; hence these glands are affected in diseases of the scrotum, while the lumbar are affected in diseases of the testes.

Practical Remarks.

The diseases of the scrotum may be here properly mentioned, as in some of them there are peculiarities which are not to be met with in the skin of other parts of the body. The most peculiar of them is chimney-sweepers' cancer;—a disease which seems to be produced from the accumulation, and consequent irritation of the soot on the skin. It has been described by authors as a malignant disease; but I am disposed rather to consider it, in its earliest stages, as merely local; and its removal at this period usually eradicates the disease, and the patient is not liable to its return, unless he again subjects himself to the same

irritating cause. On the contrary, when the disease is allowed to remain, and the surface of the wart or sore is constantly exposed to the soot, nature is foiled in her frequent attempts at reparation: the constitution becomes now affected; the sore assumes a malignant character, and the disease is propagated along the absorbents to the lumbar glands, and the patient is worn out by this additional source of irritation. Neither does it bear the character of the true malignant cancer in the period of life at which it occurs; for although, like cancer, it is not met with before puberty, yet, unlike cancer, it is not a disease of old age.

The first appearance of this disease is in the form of a warty tubercle, which secretes an ichorous discharge, producing a continued ulceration; which, if not removed and the irritating cause avoided, will go on to the destruction of life. The particular tendency of the scrotum to this disease, may be attributed to the numerous follicles it contains, and which necessarily is more prone to excitement from irritating causes.

Elephantiasis is a disease which also frequently attacks the scrotum, —probably connected with its follicular apparatus, and the quantity of cellular tissue found immediately under the skin. It occurs most frequently in warm climates, where it is indeed endemic; and has been frequently met with in Egypt, as described by Baron Larrey. It is comparatively a rare disease in cold climates. Tumours of this description sometimes acquire an amazing size, and present an irregular rugous surface, being sometimes deeply furrowed, and even ulcerated at the roots of the hairs; but the ulceration seems to be produced by the irritation of the urine flowing over its surface. If the tumour be cut into, it seems to be composed of a coagulated state of serum, accumulated in the cellular membrane, and containing very few blood-vessels; the surface of the tumour, on the contrary, is often highly vascular.

The amazingly large tumour weighing between sixty and seventy pounds, lately removed by my colleague Mr. Key, at Guy's Hospital, was, in my opinion, entirely of this kind.

Tumours of this description, in hot climates, frequently attack the pudenda in the female. I have in Guy's Hospital removed a tumour from this situation, weighing between four and five pounds, which had some of the characters of elephantiasis; but, however, differed in the greater solidity of its substance, and the size of the blood-vessels traversing its interior. It appeared rather to be a morbid growth of all the structures of the part, than a disease arising in any particular structure.

The mode of treatment which is to be recommended in the commencement of elephantiasis, consists of mercury, antimonials, acidulated

drink, and all such medicines as are known to excite the action of the absorbent system. Friction, pressure, and mercury, will therefore be found useful as local applications; should these prove ineffectual, the removal of the tumour becomes necessary; in performing which, every care is to be taken to avoid the testicles and spermatic cords if they remain free from disease, which is usually the case, as they are protected by their enclosure in a serous membrane.

Of the Testes.

The testicles are invariably two in number, and are placed within the scrotum; their office is to secrete the semen. They are of an ovoid figure, about the size of a pigeon's egg, and are suspended diagonally within the scrotum, having the upper extremity of their long axis placed forwards, and the lower backwards. They present a superior and an inferior extremity, an anterior and a posterior edge, and two lateral surfaces.

The *superior extremity* is the larger, having the head of the epididymis overlapping it, and directed slightly outwards, so that the heads of the two epididymes diverge from each other; while the rest of the epididymes are turned inwards and backwards, in a direction towards each other: hence when removed from the body, suspending the testicle by the cord, one may be distinguished from the other by observing the direction of the epididymes. The axes of the testes are three, in the direction of their length, breadth, and thickness. The length in a fully developed testicle, measures from an inch and a half to two inches; the breadth, from an inch to an inch and a half; and the thickness, from nine lines to an inch. These proportions will be found to vary in different individuals. Each testicle weighs about an ounce. The *upper extremity* is larger than the *lower;* its *anterior edge* rounder than the *posterior;* its two *sides* are convex, but present a flattened appearance when compared to the greater convexity of the anterior edge.

Their secretion and excretion of the semen is effected by the conjoined action of several structures, which may be enumerated as follows.

The *body of the testicle*—composed of the tunica albuginea which forms its immediate envelope, giving the gland form and support exteriorly, and internally to its minuter structures, by sending off tendinous septa and membranous prolongations.

The *tubuli seminiferi*, are arranged in lobes and lobules between the septa and within the membranes of the tunica albuginea, taking their course from before to behind in the short axis of the tubuli.

The *rete*—a continuation of the seminal tubes, placed posterior to the tubuli, within a duplicature of the tunica albuginea, take their course from below upwards, in the direction of the long axis of the organ.

The *vasa efferentia*—a continuation of the rete from the body of the testicle to the epididymis.

The *epididymis*—placed behind the testicle, and is divided into head, body, and tail.

The continuation of the course of the semen beyond the epididymis, will be given with the spermatic cord, and the rest of the organs of generation.

The *tunica albuginea*, is a dense, white, tendinous tunic, resembling the dura mater; it is divisible into two layers,—the outer, fibrous, dense, and presenting the metallic lustre peculiar to this tissue in every other part of the body, possessing little vascularity; the inner layer is highly vascular, the spermatic artery ramifying abundantly on it before its minuter branches penetrate with the prolongations of this membrane to the lobular structure of the tubuli seminiferi, constituting the true parenchyma of the testicle. At the upper ~~paper~~ and posterior part of the testis, and a little to its outer side, the tunica albuginea splits into two layers; the outer and more tendinous layer is directed upwards along the cord, as well as surrounding the body of the testicle; the inner layer turns inwards and forwards towards the centre of the testicle, where it forms a septum, partly dividing the lobes of the body of the testicle into two sets, and which has been very aptly named by Sir Astley Cooper, the *mediastinum testis*.

From the anterior edge of the mediastinum, tendinous septa are given off, which traverse the substance of the gland, and are attached to the tunica albuginea on the fore part of the testicle. The septa divide the tubuli seminiferi into lobes, which lobes have a covering from the inner vascular membrane of the tunic, and which gives off minute membranes to subdivide the lobes into minute lobules, and finally sheathing the tubuli themselves.

The septa are for the purpose of supporting the sides of the testicle, and maintaining the proper position of the internal structure of the gland; and this object is further attained by other smaller ligamentous processes given off in various directions from the tunica albuginea, the mediastinum, and from the septa:—these may be termed the septula testis.

The septa and septula are not only for the purpose of strengthening the structure of the testicle, but they support the vascular membrane with its ultimate distribution of vessels.

The *tubuli seminiferi* form the principal part of the interior of the testicle, and present a pulpy substance of a greyish-red color, disposed in lobes of a pyramidal form; their bases being turned toward the lateral parts of the tunica albuginea, and their apices toward the mediastinum; being maintained in their situation by the vascular membrane enclosing them, and the septula supporting them. So minute are the tubuli contained within these lobuli, that, according to Munro's estimation, their calibre is not more than 1-200th part of an inch in diameter: they do not ramify, but are composed of innumerable convolutions; the total length of which, when unravelled, have been estimated at 5,200 feet. These tubes terminate in the apices of the pyramidal lobes at their junction with the mediastinum; and when they enter the substance of the mediastinum, are called the rete.

The *rete*.—In this situation the vessels of the rete take two directions: first passing parallel with the mediastinum, from before to behind, then turning upwards in the direction of the long axis of the testicle, they pass to terminate in the

vasa efferentia. In the first direction they are enclosed within the mediastinum; but in their second, they are in that part which has been hitherto termed the corpus highmorianum.

The *vasa efferentia* are the continuations of the seminal canals from the upper and anterior extremities of the rete to the head of the epididymis, into which they terminate: they are from thirteen to fifteen in number; and it is stated by Sir Astley Cooper, that, from numerous dissections, he never found them more than fifteen; although Cloquet asserts that they sometimes amount to thirty. In consequence of disease they become obliterated, and have been found so few as six or seven in number: they arise separately from the rete, and terminate in the single tube of the epididymis. At first they present a single tube, which is but very slightly convoluted; but which, as it reaches the epididymis, is divided into numerous minute convolutions, each forming a conical mass or lobe, somewhat similar to the lobes of the tubuli seminiferi, but differ in this respect: that the bases of their cones are turned toward the epididymis, and their apices toward the rete. *(Vide diagram I. pl.* 2.*)*

The *epididymes*—so named from their covering the didymi or testes: they are rounded oblong bodies, attached to the posterior part of the testicles. They present a posterior rounded convex edge, an anterior thinner concave edge, a superior extremity or head which overlaps the testicle, a middle portion which is named its body, and a lower extremity which is called its tail or cauda. The epididymis is covered by the tunica vaginalis in the same manner as the testicle, which will be described when speaking of the descent of that organ from the abdomen. The vasa efferentia fill the epididymis, and are disposed in lobes, which are separated and supported by tendinous septa and septula, much in the same manner as the lobes of the tubuli within the body of the testes.

These lobes are so numerous at the upper part of the epididymis, that they here produce the enlargement termed the head, and which projects towards the outer surface of

each testicle. In the body of the epididymis the lobes are more distinct, and may be readily unravelled; and, as it approaches the tail, the tube becomes larger in its calibre, and finally terminates in the vas deferens. Occasionally prolongations are found, from one to three inches in extent, passing from the body of the epididymis along the vas deferens, and terminating in blind pouches.

The seminal tubes having left the testicle form the vas deferens, when it immediately becomes situated at the posterior part of the spermatic cord, which being made up of other structures essentially connected with the testicle, should now be traced throughout its course.

The Spermatic Cord

Has already been referred to as suspending the testicle within the scrotum: it is made up of blood-vessels, nerves, absorbents, and the excretory duct, united by cellular membrane and covered by tunica vaginalis. It proceeds from the back part of the epididymis, rising above the testicle and enclosed within the layers of the scrotum, reaches the external abdominal ring; thence traversing the inguinal canal, and passing underneath the free edges of the internal oblique and transversalis muscles, gains the internal ring and abdominal cavity; where its character, as a cord, becomes lost by the separation of its constituent parts. The parts thus entering into the composition of the cord, and considered individually, are the spermatic artery, derived from the aorta; the spermatic vein, returning the blood not consumed in the secretion of semen into the general circulation; the nerves, derived from the sympathetic and lumbar plexus; the absorbents, passing to the lumbar and hypogastric glands; and the vas deferens, which, directly it has reached the abdominal cavity, separates itself from the cord, winds behind the epigastric artery, and descends along the side of the bladder, to reach the prostate gland. To trace the connection between the external and internal organs of generation, it becomes necessary to obtain a lateral view of the organs contained

within the pelvis; but however, before this is done, it would be better to trace the progress of the testicle from the abdomen into the scrotum.

Descent of the Testicle.

The testes in the fœtus are placed in the same situation as the ovaria in the female: immediately below the kidneys, upon the fore part of the psoæ muscles. While in this situation, like all the other organs contained within the cavity of the abdomen, they are placed behind the peritoneum; receiving a close covering, excepting at their posterior part, where a space is left for the entrance of their vessels. But as this organ is destined to change its situation within the abdomen for one within the scrotum, we shall find a structure superadded, which is supposed to assist in the descent of the testicle, and which passes from the lower part of the body of the testicle and epididymis, behind the peritoneum, along the parietes of the abdomen into the scrotum, where it is spread out and lost. This structure has been named the *gubernaculum*, from the supposition that it guides the testicle into the scrotum; but, in the descent, nothing is apparent which indicates any forcible dragging down; on the contrary, in their whole descent, the vessels preserve their tortuous course. This process appears one of natural growth, and belonging to a particular period; for should any circumstance interrupt nature in her work at this period, she does not appear after, capable of exerting it, and the testicles remain within the abdomen during life. In the earlier periods of uterine gestation, the testicles are placed immediately below the kidneys, nearer to the origin of the spermatic artery than at any after period: the artery is even then, although so near its destination, found to take its peculiar tortuous course. Besides the gubernaculum, the cremaster muscle passes from the abdominal muscles, behind the peritoneum, to be inserted into the lower and back part of the testis and epididymis, and is also attached to the peritoneum. At the fifth or sixth month the testes are found upon the

lower part of the psoæ muscles: the gubernaculum appearing to have become contracted or absorbed; while the cremaster muscle, by being drawn down, is formed into loops, which consequently surround the testicle in the manner of slings. This peculiar structure of the cremaster muscle has been first described, demonstrated, and beautifully delineated in the work on the testis, lately published by Sir Astley Cooper. About the eighth month or a shorter period before birth, the testicles descend into the scrotum: first having passed the internal ring, they are found in the inguinal canal, where they appear to receive a check to their progress, remaining in this situation for a greater or less period before they pass the external ring into the scrotum. While within the inguinal canal, the fibres and loops of the cremaster muscle form a complete bag or pouch surrounding them; and which bag, testicles, and the loose peritoneum of the anterior parietes of the abdomen, descend together into the scrotum. *(Vide diagrams, pl. 2.)* But it is to be remembered, that the testicle does not fall into a loose bag of peritoneum as a congenital hernia, but that it is placed behind the cavity formed by the pouch of the peritoneum, which is drawn down with the testicle, precisely in the same manner with respect to it, that it was, while within the cavity of the abdomen; excepting that the reflected portion of the peritoneum is much closer to that portion which is in contact with the testicle in the scrotum, than it was in the abdomen, from its having been drawn down, lengthened and narrowed in its descent. The peritoneum which is thus drawn down with the testes, is termed the tunica vaginalis: that part of it which is in contact with the testicle, is called the tunica vaginalis testis: while that in contact with the scrotum, is termed the tunica vaginalis reflexa or scroti:—a cavity being left between the two layers, in which a vapour is poured out, as in other serous cavities, to facilitate the motion of the parts. At first, after the testicle has descended, the bag of the tunica vaginalis and of the peritoneum communicate; but in a short time the neck of the vaginal bag, at the internal ring, sets up

an adhesive inflammation, and the two cavities are shut out from each other. That this adhesive process commences at the internal ring, is proved by the water in the hydrocele of young children passing much higher up than in after life; for the adhesion of the pouch goes on gradually, till it obliterates the canal along the cord to the testicle. This obliteration does not, however, always take place; so that after the descent of the testicle, the vaginal and peritoneal bag may still communicate: in which case the patient is liable either to the escape of intestine, or to the formation of fluid between the two layers of the tunica vaginalis. The first disease is termed congenital hernia, and the second congenital hydrocele. They are both usually to be radically cured by the same treatment: namely, that the contents of the bag should be returned into the cavity of the peritoneum, and a truss be constantly worn, night and day, to promote the closing of the opening. It is safer, and should therefore be recommended, that the truss be worn to the age of puberty.

Sometimes the obliteration only partially takes place, closing the opening from the abdomen, but not extending along the tunica vaginalis of the cord: and again, it may happen that the obliteration will occur at the two rings only, leaving a cavity between them in the inguinal canal. An accumulation of fluid may take place in this situation, and is termed hydrocele of the cord.

There is some difficulty in forming a just diagnosis in these cases, the tumour being precisely in the situation of a bubonocele; but the absence of any functional derangement in the intestines, and the transparency of the swelling, are to be considered as the guiding marks. Should the transparency, however, not be perceptible, it is to be considered as highly rash to puncture the swelling; for as there are no urgent symptoms, the danger of opening an intestine should be avoided.

The testicles sometimes do not descend until the period even of twelve or fourteen years, or it may happen that only one has descended: in both instances there is a liability to

the protrusion of intestine with the testicle. Nor is it of very rare occurrence that the testes should never leave the abdomen. John Hunter thought, that in such cases there was some imperfection in them; and that they had not therefore the power, or, as he termed it, the disposition to descend; not being actuated by the "stimulus of necessity." But this does not appear to be the case, as there are several instances recorded in which the testes, under such circumstances, were found fully developed. It involves, however, a curious physiological question, whether persons under these circumstances are or are not to be considered as sterile.

This completes the subject as connected with the testicle: and we shall now proceed, as proposed, with the anatomy of the side view of the pelvis.

Side View of the Pelvis.

The dissection of the side view of the pelvis is prosecuted by separating the left os innominatum from the sacrum, at the sacro iliac symphysis, and by cutting through the symphysis pubis, and continuing the incision through the perineum to the left of the urethra and rectum, so as to remove the extremity, leaving the genital organs and the contents of the pelvis in their relative position, connected with the right wall of that cavity.

Before entering into a consideration of the contents of the pelvis, it will be well for the student to reconsider the bony parietes of this cavity, and to bear in mind the changes of position of which it is capable in relation to the trunk and extremities, and the different directions which the axes of its outlets assume during these changes: a knowledge which alone can give confidence to the hand of the surgeon, when directed by the mind, unassisted by the eye.

The bladder should now be moderately inflated from the ureter, and the rectum distended with horse-hair, so as to preserve its cylindrical form without destroying its natural curve. The loose cellular membrane should be removed, so as to display the relative position of the viscera: which

consist of the bladder with the terminations of the ureter, the prostate gland, the membranous portion of the urethra, the vas deferens, and the vesicula seminalis: these parts being bounded below and behind by the rectum.

The *bladder* is the organ which should now be described, as it belongs both to the second and third class of viscera contained within the abdomen. To the second class it performs a most important function, as a reservoir for the urine; and to the third class, namely, the generative organs, it is essential from its intimate connection with the prostate gland and vesiculæ seminales, as well as from its giving origin to the urethra.

The bladder is a musculo membranous bag or reservoir, capable of considerable distention and contraction, and destined to receive the urine. It is situated within the cavity of the pelvis under the usual circumstances of its distention, but may extend into the umbilical region from great accumulation of urine. It is bounded *above*, by the small intestines; *below*, by the prostate gland, vesiculæ seminales, vasa deferentia, and rectum; *before*, by the pubes; *behind*, by the rectum, and that portion of the small intestines contained within the *cul de sac* of peritoneum which passes from the posterior surface of the bladder to the middle anterior surface of the rectum. This *cul de sac* in the female is formed into two pouches by the uterus and vagina. Such is the usual description given of the boundaries of the bladder; but from its diagonal direction, both as it regards the viscus itself, and the position of the pelvis in relation to the spine, it results, that its upper boundary is formed partly of the posterior as well as the superior; and the anterior boundary, partly by the inferior: that is, by the perineum as well as by the pubes.

The form of the bladder varies remarkably at different ages and in the different sexes: in the adult male it is conical; in the adult female more capacious, particularly in the direction from side to side, giving it more of a globular than the conical form: in young children it approaches to a

cylindrical form, probably from its being seldom distended by any great accumulation of urine.

The bladder in an empty state, from the pressure of the small intestines has its posterior surface pressed forwards upon the anterior, so as to produce a great diminution of its antero posterior axis, and to represent a flattened form. From this state the accumulation of urine produces distention in the following order:—at first the inferior and posterior part of the bladder begins to enlarge, in consequence of its meeting with less resistance in this direction, and from the gravitation of the urine itself: as the accumulation goes on, the bladder still increases in its axis from before to behind, its progressive increase being from below upwards; and when the upper part becomes distended, the bladder then assumes a globular form, at which stage it contains from eight to ten ounces of fluid, which commonly produces a desire for its expulsion. The further progress of distention will be found to be more particularly governed by the attachments of the peritoneum furnishing a firm resistance in every direction excepting at the superior parts, where the enlargement in extreme distention takes place, so that the bladder rises from the pelvis into the umbilical region, and will even form a conical body, projecting between the peritoneum and the inferior part of the parietes of the abdomen above the pubes.

As this subject involves so many points of interest, I have further explained it by an annexed diagram. *(Vide diagram I. pl.* 3.*)*

For this account of the progressive mode of the distention of the bladder, I am indebted to my friend the Baron Heurteloup.

The external surface of the bladder, from its numerous anatomical and surgical relations in which there are so many points of importance, has been necessarily subdivided into different regions, which should now be particularly examined.

The *superior region* or fundus, is that portion of the bladder which is constantly in contact with the small intestines,

and which rises into the umbilical region under circumstances of extreme distention. Its summit is marked by the attachment of the urachus, which, at the same time that it divides this region into an anterior and a posterior portion, acts as the principal suspensory ligament to the bladder. Posterior to the urachus, the fundus is covered with peritoneum: anterior to it, the bladder is destitute of peritoneum; and it is in this space that it may be punctured when that operation is performed above the pubes. On either side of the urachus is also found an impervious cord, the remains of the umbilical artery; which also marks the division of the fundus into an anterior and a posterior half, as well as the boundary of the attachment of the peritoneum.

The *inferior region* is a triangular space, bounded in front by the prostate gland; behind, by the reflection of the peritoneum from the bladder to the rectum; and laterally, by the vasa deferentia and vesiculæ seminales. This space rests upon the rectum, with which it is connected by cellular membrane; and is of importance from its being the part punctured when the operation for the retention of urine is performed per anum; and also, from its being liable to be raised by enlargements of the third lobe of the prostate, producing retention of urine: to relieve which, the bladder should never be punctured per anum. In the female, this region of the bladder rests upon the vagina, and is anteriorly bounded by the meatus urinarius.

The *anterior region*, is that portion of the bladder which is connected with the pubes by the posterior layer of the deep fascia of the perineum, and by condensed cellular membrane and fat. Above, the fascia is termed the anterior ligament of the bladder, and extends from it over the prostate gland. This region is bounded above, by the anterior half of the fundus; below, by the prostate gland; and in front, by the pubes.

When the membranous portion of the urethra gives way within the pelvis, the course of the extravasated urine, or formations of matter, is directed between the bladder and rectum;

as the deep fascia of the perineum, and anterior ligament of the bladder, prevents its passage forwards to the perineum, or upwards behind the pubes.

The *posterior region* is entirely covered by peritoneum: it is bounded *above*, by the posterior portion of the fundus; *below*, by the inferior region; and is marked at the line of reflection of the peritoneum from the bladder to the rectum, or by a line drawn from the base of one vesicula seminalis across to the other. In the male it is separated from the rectum, more or less, by convolutions of the small intestines, and in the same manner in the female from the uterus.

The *lateral region* of the bladder may be designated as that portion of the viscus which receives the terminations of the ureters, and have the remains of the umbilical arteries and the vasa deferentia traversing their surfaces, anterior to the reflection of the peritoneum from the bladder to the rectum. These regions are necessarily bounded by the four others which we have already described, and are opposed to the levatores ani, and condensed cellular membrane at the sides of the pelvis.

The *neck* of the bladder constitutes that conical part which is surrounded by the prostate gland, and which is situated behind and below the arch of the pubes: it is more horizontal in its direction in the adult than in the period before puberty. In the female, this portion of the bladder, from the absence of the prostate gland, seems to be merely the conical termination of the organ before it ends in the meatus urinarius.

In the operation of lithotomy, if the section through the prostate gland be complete, the neck of the bladder is necessarily cut into.

The connection of the ureter with the kidney has already been described; but its course from that organ to the bladder was necessarily postponed until we had the opportunity of its demonstration in the side view of the pelvis.

The *ureters* are the excretory ducts to the kidneys, and are long membranous tubes about the size of a goose-quill: they

y. are said to be composed of two coats, external [illegible]
[illegible], internal mucous. [illegible]

commence from the pelvis of the kidneys, from which they are directed immediately downwards behind and below the renal vessels. They take their course downwards and inwards as far as the sacro iliac symphyses, where they turn into the cavity of the pelvis, to reach the lateral regions of the bladder to terminate in that viscus. The ureters, in their course, at first are placed upon the psoæ muscles as far as the sacro iliac symphyses; just above which, they cross the common iliac vessels; and as they gain the cavity of the pelvis, they pass over the internal iliac artery and vein, taking their course to the posterior part of the inferior region of the bladder, having behind them only fat and cellular membrane: but just before they terminate, in the male, the vasa deferentia pass around them, to reach the vesiculæ seminales. They are covered, while on the psoæ muscles, by the peritoneum; and as they are crossing the iliac vessels, the spermatic artery and vein pass in front of them.

The peculiar circumstances attending the opening of the ureters into the bladder, will be best seen and described when studying the organization of the bladder, and the parts are removed from the pelvis.

In the progress of the description of the side view of the pelvis in the male, we have next to describe the

Prostate Gland:

A part of great surgical importance, both in relation to operations and to its diseases.

Its form is that of a chesnut, or heart-shaped, being rounded at its posterior base, and more pointed anteriorly: its long axis is about an inch, and is placed nearly horizontally, but having a slight inclination forwards and downwards. It is bounded *above*, by the anterior region of the bladder, and its ligament; *below*, by the rectum; from which, however, it is separated by the posterior layer of the deep fascia of the perineum; *behind*, by the neck of the bladder, which it partly surrounds, with the termination of the vesiculæ seminales and vasa deferentia; *before*, by the

membranous part of the urethra; and *laterally,* by the levatores ani.

The *vesiculæ seminales,* are two membranous bodies of an irregular conical form, about two inches in length, placed on the inferior region of the bladder, of which they form the lateral boundaries: they diverge posteriorly, and converge anteriorly, as they approach the prostate, in which they terminate. They are bounded *above,* by the bladder; *below,* by the rectum; *before,* by the prostate gland; *behind,* by the reflection of the peritoneum from the bladder to the rectum, and by the termination of the ureters; on the *inner* side, by the vasa deferentia; and on the *outer,* by the levatores ani. They are held in their situation by the fascia which passes from the posterior layer of the deep fascia of the perineum, continued to them from the prostate.

We have here also to notice the course of the vas deferens, which we have already described as far as its entrance into the cavity of the pelvis. (*Vide* page 115.)

From the internal ring it makes an acute angle, turning downwards and inwards, at the same time leaving the spermatic artery and vein. When within the inguinal canal, the vas deferens rested upon the fascia transversalis, and consequently anterior to the epigastric artery; but having passed the internal ring, it winds around that vessel, enclosing it in its angle, and is then situated on its inner side. The vas deferens, from this point, passes to the lateral regions of the bladder, continues in contact with that organ, passing downwards behind the termination of the ureter, between it and the bladder; from whence it proceeds along the inferior region to the inner side of the vesicula seminalis, with the duct of which it terminates in the prostatic portion of the urethra, in a manner which will be more particularly described with the organization of these parts.

To complete the description of these organs, it is necessary for the pupil to observe in the side view of the pelvis, the relative situation of the rectum, which, instead of being straight in its course, as its name implies, forms a complete

curve; the first third of its length passing from the anus to the os coccygis, is straight, lying beneath the posterior half of the membranous portion of the urethra, the prostate gland, the neck of the bladder, vesiculæ seminales, and termination of the vasa deferentia: the middle third lies in the lower portion of the hollow of the sacrum, and is curved, presenting its convexity backwards and upwards, and its concavity forwards towards the bladder: the superior third, which commences at about the second bone of the sacrum, passes upwards with a slight obliquity forwards, obeying the bend of the sacrum, to reach the lumbo-sacral articulation, where it terminates in the sigmoid flexure of the colon.

Having described the relative position of the contents of the pelvis, the student should now take an articulated pelvis, and place it in a corresponding position to that of the subject; and which position should be precisely that adopted in the performance of operations on the urinary organs.

In the erect posture of the body the axis of the pelvis, in its upper and anterior outlet, forms an acute angle with the perpendicular line of the spine; while the axis of the lower or posterior outlet, forms a very obtuse angle with the same perpendicular line. *(Vide diagram I. pl. 4.)*

In a full sized male pelvis now before me, the following points appear to be most worthy of remark, in relation to the operations on this part of the body. The highest points of the crista of the ilia rise above the sacrum to a level with the middle of the body of the fourth lumbar vertebra: a line drawn from the anterior and superior spinous process of the one ilium to the other, is on a horizontal plane with the junction of the last lumbar vertebra with the sacrum, at a distance of two inches and a quarter anterior to it; while it is, on a perpendicular plane, four inches above the symphysis pubis. The distance across the cavity of the pelvis, from the superior part of the symphysis pubis to the junction of the sacrum with the os coccygis, is five inches and a half; while the distance from the arch of the pubis to the same point, is four inches and six eights: these two admeasure-

ments shew the obliquity of the symphysis pubis, in relation to the cavity of the pelvis; and which obliquity is one cause of the diminution of the lower in proportion to the upper outlet. From the arch of the pubes to the point of the os coccygis, is three inches and six eights; while from the symphysis pubis to the same point measure five inches, and is very nearly on a horizontal plane. It may be worthy of remark, that in the direction of a line drawn from the arch of the pubes to the extremity of the os coccygis, the lower opening of the pelvis is principally enlarged during parturition.

These points having been observed in the erect position of the skeleton, we shall now apply them to the pelvis, and the viscera it contains, in reference to surgical operations.

The position should be such that the axis of the pelvis, instead of forming an acute angle with the perpendicular line of the spine as in the erect posture, should be brought parallel to it or nearly so; as is the case when the pelvis is slightly raised and the thighs flexed, in the recumbent position of the body. *(Vide diagram II. pl. 4.)*

When the subject is thus placed, the lower opening of the pelvis is immediately presented to view; and from the changed direction of its axis, in relation to the spine, the surgeon gains the advantage of the whole circumference of the lower outlet. It is in this position that the following admeasurements of the inferior outlet of the pelvis should be particularly borne in mind. In the recent subject, the tuberosities of the ischia present the most prominent points of the lateral boundaries, and are distant from each other from three and a half to four and a half inches; while the perpendicular axis, constituting, in the recent subject, the space occupied by the perineum and anus; and, in the skeleton, between the arch of the pubes and extremity of the os coccygis, are, in this position, nearly in a perpendicular line, and on a plane two inches posterior to the line drawn from the one tuberosity of the ischium to the other. In the posture in which we are now considering the pelvis and recent

subject, the line from one tuberosity to the other divides the lower outlet of the pelvis into an upper and a lower portion; which, in the erect posture, are anterior and posterior. The upper portion constitutes the perineum, and is connected with the genital and urinary organs: the lower contains the anus, and is connected with the process of defecation. The perineum is seperated from the cavity of the pelvis by its deep fascia; leaving, however, an opening for the passage of the urethra, immediately under the arch of the pubes; and below, forming a crescentic edge over the superior surface of the rectum.

If the upper portion of the outlet be divided by a perpendicular line drawn from the arch of the pubes to the imaginary line already spoken of,—from one tuberosity to the other,—the precise direction of the raphé of the perineum is pointed out, which may be considered by the surgeon as his director through all the intricacies connected with the operations of those parts: leading him into the urethra either anterior to the bulb, into the bulb itself, or into the membranous portion of the urethra. *(Vide diagram III. pl. 4.)*

Before we remove the bladder and organs of generation from the cavity of the pelvis, in order to study their organization, it will be necessary to observe the attachments of the penis, and course of the urethra from the penis to the bladder.

The *penis* is one of the external organs of generation, and is attached to the symphysis pubis by the suspensory ligament, and to the rami of the ischia by its crura. Between the two diverging crura of the penis, the bulb of the urethra is placed; from the posterior part of which, the membranous portion passes through an opening in the deep fascia of the perineum to the prostate gland, which surrounds it.

The side view of the perineum being exposed as well as the side view of the pelvis, their connection, maintained by the passage of the urethra under the arch of the pubes, should be carefully observed; and also the situation of the muscles of the perineum, which have been particularly described. *(Vide* Vol. II. p. 173.)

The urinary and genital organs connected with the pelvis should now be removed, in order to examine their minute organization; in doing which, the bladder should be detached, the ureters and vasa deferentia cut through, leaving the bladder connected with the penis, which must be carefully dissected from its attachments; at the same time, examining the crura and suspensory ligament.

The Organization of the Bladder.

Its relative position, and its regions, being already described, we have now only to speak of its organization.

The bladder is composed of three coats, one of which is however only partial: these coats are the serous, the muscular, and the mucous.

The *serous* coat only partially covers the bladder, in a manner that has been described when speaking of the reflection of the peritoneum, of which this covering is formed. It passes from the anterior parietes of the abdomen to be reflected upon the upper posterior, and the posterior portions of the lateral regions; leaving the anterior, anterior portions of the lateral, and the whole of the inferior regions of the bladder uncovered. It is attached to the second, or muscular coat, by cellular membrane of rather a loose texture, which surrounds the remaining portion of the viscus, constituting, by the description of some anatomists, a distinct coat, and proceeding principally from the ligaments of the bladder.

The *muscular* coat is, both in color and thickness, very similar to the muscular coats of the stomach and intestines; disposed in various directions, so that their united contractions may tend to diminish the capacity of the organ in every direction, and equally press upon its contents. The greater number of these fibres pass in a longitudinal direction: they are thickest and most numerous at the neck of the bladder, and comparatively but a few appear to pass in a transverse direction. Several fibres may be seen in the mesian line of the bladder, passing from the prostate gland and neck

towards the urachus: the remainder from the lateral parts of the neck, ascend to the superior region, where they meet, and even cross each other, before they are gradually lost. The thickened portion of these fibres, which constitute as it were the muscular paries of the neck, has by some anatomists been described as the sphincter vesieæ. The muscular is connected with the third, or mucous coat, by a whitish, dense tissue of cellular membrane.

The *mucous* coat of the bladder is continuous with the membrane lining the ureters and urethra. It is thin, whitish and delicate, covering the interior of the organ; and in the collapsed or empty state of the bladder, assumes innumerable minute wrinkles or rugæ. This membrane is lubricated by mucus, to defend the organ from the irritation of the urine. The villi and follicular apparatus are very minute, and are scarcely distinguishable, excepting in certain cases of disease, when they are rendered manifest.

There are three openings into the bladder, placed at its inferior region, one anteriorly and two posteriorly, describing between them a triangular space, which has been termed by Lieutard, *la trigone de la vesie*, and which space corresponds to the external surface of the inferior region of the bladder: here the mucous membrane has little or no rugæ, and its sides are marked by two thickened projections, which are caused by corresponding enlarged muscular fibres passing from the termination of the ureters towards the neck of the bladder; these have been considered by some anatomists to be for the purpose of regulating the flow of urine into the bladder.

The terminations of the ureters into the bladder form somewhat of an oval opening, which is prolonged between the mucous and muscular coats for the space of an inch, which construction answers the purpose of a valve to the ureters; for as the bladder becomes distended, this canal is compressed, the mucous membrane being fixed against the muscular coat.

The *arteries* of the bladder arise from the branches of the

internal iliac; they take a tortuous course, and are most numerous towards the inferior portions of the lateral regions.

The *veins* are more numerous than the arteries, and form a very considerable plexus, which is termed the hypogastric; and from which veins pass to terminate in the venous trunks, corresponding to the course of the arteries.

Its *nerves* are derived from two sources, the hypogastric, and lumbo-sacral plexus; the former furnishing it with its involuntary, the latter with its voluntary powers.

Its *absorbents* terminate in the hypogastric ganglia.

The organization of the prostate gland.—This gland has no proper capsule, but is held together by a dense cellular membrane, giving it great firmness; it is attached *above*, to the anterior ligament of the bladder, which invests its upper surface; *below*, it is covered by the posterior layer of the deep fascia of the perineum, which connects it with the upper surface of the rectum. When cut into, its color is a yellowish grey, and appears to be made up of a mass of numerous follicles, which secrete a viscid fluid of a whitish color. The excretory ducts of these follicles are about fifteen in number; they are directed obliquely forwards, and terminate within the prostatic portion of the urethra, by the sides of a projection termed the *veru-montanum* or *caput gallinaginis*. On compression, the secreted fluid of this gland may be seen to exude from the orifices of its ducts.

We have already observed, that the general figure of the prostate gland is that of a chesnut, or heart-shaped; it is divided by a longitudinal fissure into two lateral lobes,—this fissure being much more defined on the inferior than on the superior surface: at the posterior part or base of the inferior surface, a small process connects the two lateral lobes; this is described as the third lobe of the prostate, and is remarkable for its enlargement in advanced periods, frequently increasing to the size of the rest of the gland; pressing, in such instances, the inferior region and trigone of the bladder upwards, so as to form an impediment to

the passage of the urine into the urethra. The urethra traverses the prostate from behind to before; but not immediately through the centre of the gland, but nearer to its upper than to its lower surface. The terminations of the ducts of the vesiculæ seminales and vasa deferentia, enter at the posterior portion or base of the prostate, traversing its substance in a canal, which is directed forwards, terminating in the urethra. Whether the secretion from the prostate gland be necessary to generation, or whether it be merely to lubricate the surface of the urethra, is a physiological subject not well understood.

Organization of the vesiculæ seminales.—They are covered by a dense external coat, similar in structure to the exterior of the vas deferens, but somewhat thinner and more transparent; their inner coat is nearly white, very thin, and is a continuation of the genito-urinary mucous membrane, and has been compared in this situation, to the inner coat of the gall-bladder.

The vesiculæ seminales are made up of several conical or pyriform cavities; these join together, forming a neck or elongated extremity, which passes forwards to be united with the vas deferens, with which they terminate as a common duct. When the vesiculæ are cut open, they present an appearance as if made up of numerous cavities; but this appearance is the result of various sections being made of a single convoluted tube; as is proved by the possibility of their being unravelled in the same manner as the epididymis. The secretion of the vesiculæ seminales is a yellowish opaque fluid, having a peculiar smell, and of a browner color than the semen. They were considered formerly as merely reservoirs for the semen; but John Hunter found that they were filled with the same fluid in persons whose testicles had been removed: he conjectured, therefore, that this fluid served the purpose of a vehicle in the passage of the semen. Such conjectures, with many others that have been entertained upon this subject, serve only to prove that the function of the vesiculæ seminales is

not understood. Certain animals are without these organs, as in the carnivora and ruminantia.

Cowper's glands—are two ovoid glandular bodies, situated at the back part of the bulb, and on the sides of the membranous portion of the urethra. They are of a pinkish color, and about the size of peas. Their surface is rather uneven, similar to a conglomerate gland; and they have been compared to the salivary glands. The excretory duct of each is about an inch in length, and passes obliquely forwards to terminate in the urethra, anterior to the membranous portion. They secrete a fluid which is discharged with the semen, but the use of which is wholly unknown. They are often wanting.

A small gland of the same nature has been mentioned by Cloquet to have been met with in the angle formed by the union of the roots of the corpora cavernosa. Like the vesiculæ seminales, in some animals they are found of large size, or numerous; while, in others, they are altogether wanting. But carnivora and ruminantia, which are deficient of the vesiculæ seminales, are furnished with Cowper's glands.

Of the Penis.

The *penis* has a double office to perform, being destined to convey the semen for the purpose of propagation, to the female, as well as to act as an excretory organ to the bladder. For the first object, a peculiar state of the organ is essential to the act; and we shall find, therefore, a structure capable of being distended under such excitements only as lead to the desire for the other sex: while, on the contrary, to perform the duties of an excretory canal to the urinary bladder, it may be considered completely as passive, the muscles of the bladder and abdomen being the active organs in micturition.

The penis is of a cylindrical form, is attached by what is termed its root to the pubes; its free or anterior extremity is formed by the glans and prepuce, and the intermediate

space is termed the body. In the ordinary state, it is pendulous in front of the scrotum.

Organization of the penis.—It is composed of *integument*, which forms a general envelope; of the *corpora cavernosa*, which form the upper part and sides of the body; of the *corpus spongiosum*, which is placed inferiorly, and terminates in the *glans;* and of the *urethra*, which passes through the whole length of the organ.

The *integument* of the penis is continued from the scrotum and pubes; it is very thin, darker colored than the integuments of the other parts of the body; towards the root is furnished with numerous sebaceous follicles, and with a few hairs, which are directed forwards. At the under part of the penis there is a projection in the skin, termed the raphé, which is continuous with that of the scrotum. The integuments project beyond the free extremity of the penis, terminating in an opening which prolongs itself over the glans, and forms what is termed the *prepuce*; it is attached to the under part of the glans by a fold or puckering of the skin, called the frænum, and which is continued nearly to the opening of the urethra.

The prepuce is composed of an external cutaneous and of an internal mucous layer, connected with each other by an intervening cellular tissue. The internal mucous lining, commences from the anterior extremity of the prepuce, around its aperture, proceeds backwards to the corona glandis, is reflected over the glans, and terminates at the opening of the urethra, by becoming continuous with it: where it is reflected from the prepuce to the corona glandis, it forms a *cul de sac;* which, on the three upper fourths, is applied against the corpora cavernosa; but its inferior fourth is lengthened to form the frænum, and proceeds along the glans as far as the urethra. Immediately behind the corona glandis, and beneath the prepuce, are situated a number of small sebaceous glands in rows, which are termed the glandulæ odoriferæ or Tysoni: they are about the size of a mustard seed, and secrete a thick unctious humour of a very fœtid

smell, which lubricates the surfaces of the glans and prepuce. Beneath the skin of the penis is a superficial fascia, which is continued above, from the superficial fascia of the abdomen; and below, from the dartos of the scrotum: it extends around the penis as far as the corona glandis; it is sufficiently loose to allow of the free motion of the skin of the organ. Anteriorly and at the upper part of the root, this fascia is thicker than at the other parts, and forms a kind of superficial suspensory ligament.

The *corpora cavernosa* constitute the principal part of the penis, forming two-thirds of the bulk of the organ, and is the part which, by its distention, produces erection. They are two cylindrical bodies, closely applied to each other, extending from the rami of the ischia and pubes, to the glans penis.

The commencement of the corpora cavernosa are termed the crura, and are attached to the whole length of the rami of the ischia and pubes; in the course of which attachment the two cylindrical bodies are separated, but converge as they approach the arch of the pubes, immediately beneath which they unite to form one body; and in the under part of the angle, formed by their union, the bulb of the urethra is placed. At the upper part of the union of the crura of the corpora cavernosa, the *ligamentum suspensorium* is attached, which connects them with the symphysis pubis: it is of a triangular figure, arising from the symphysis, and is inserted into each crus: it consists of two laminæ, between which the dorsal vein and nerves of the penis pass. The corpora cavernosa, in the body of the penis, are united by a septum, called the pecten; which commences at the symphysis pubis, but does not reach so far as the glans; a little before which they again separate, terminating in two rounded extremities, which are capped by the glans penis. This septum does not form a complete separation, being made up of parallel and vertical fibres; between which are openings, allowing, under certain circumstances, the transmission of fluids from one corpus to the other.

The union of the corpora cavernosa is further marked by a superficial groove on the upper part or dorsum, which lodges the dorsal vessels and nerves; and by a deeper groove inferiorly, which partly surrounds the corpus spongiosum and urethra. The corpora cavernosa are covered by an elastic fibrous sheath, composed of fibres which pass principally in a longitudinal direction, and are continued from the periosteum of the ossa ischia, and from the tendinous insertions of the erectores penis muscles: it is not of the same density throughout; being attenuated and more transparent in the groove which receives the corpus spongiosum, and the extremities which contain the glans.

The substance of the corpora cavernosa is made up of a spongy tissue, which fills this fibrous membrane. Considerable difference of opinion exists with regard to the ultimate structure of this substance; but it appears to be a multitude of cells, composed of a complicated lace-work of arterial and venous vessels, with filaments of nerves, supported by minute fibrous laminæ, continued from the exterior fibrous tunic, and which does not very much differ in structure from the tunica albuginia of the testicle; being also for the purpose of giving support and strength to the interior organization. The cells of each corpus cavernosum freely communicate: an injection thrown into the artery readily fills both veins and cells: whence it has been conjectured that these cells are intermediate between the arteries and veins. This is not, however, satisfactorily proved; for it is still considered by some physiologists, that these cells may be formed by a peculiar tortuous arrangement of the vessels themselves.

Corpus spongiosum urethræ, is a cylindrical body, enclosing the urethra, and situated below and between the corpora cavernosa; it does not, however, enclose the whole length of the urethra, the posterior fourth of that canal being placed behind and below it. This spongy body commences by a large conical projection, placed between the crura of the corpora cavernosa, and behind their union; it is called

the *bulb*, and extends from the root of the penis to near the anus. This portion of the corpus spongiosum first receives the anterior extremity of the membranous portion of the urethra, the sides of which it overlaps, and has placed between it and the urethra, on either side, Cowper's glands. It then becomes contracted, and extends as far as the anterior extremities of the corpora cavernosa, as a uniform cylindrical sheath, where it expands itself into a large conical formed body, which is termed the glans penis.

The *glans* has the form of a truncated cone, presenting a base posteriorly, which overlaps the corpora cavernosa, and is separated from them by a furrow, which may be termed the cervix, and in which the glandulæ odoriferæ are placed. A prominent edge or margin terminates the glans posteriorly, forming what is designated the corona glandis. The superior surface of the glans is nearly twice as long as the inferior, which forms a projection before mentioned, under the name of the frænum preputii. The apex of the glans forms a pointed termination, which is pierced by the urethra. The corpus spongiosum is covered by a fibrous tissue, in a similar manner to the corpora cavernosa: in its internal structure it seems to be composed of a minute interlacement of capillary vessels, either connected by, or ramifying on a delicate cellular tissue, but capable of receiving a considerable quantity of blood, so as to produce its general distention: hence it has been termed an erectile tissue.

The *urethra* is the excretory canal, both for the urine as well as for the semen, extending from the neck of the bladder to the apex of the glans penis. In taking this course it does not pass in a straight direction, but forms incurvations, the situations of which it is essential for the surgeon to perfectly comprehend. The urethra, when it first leaves the bladder, is directed slightly downwards, to enter the prostate gland, gaining here the name of the *prostatic portion*, which is from an inch to an inch and a half in length, running through the substance of the gland somewhat obliquely, and firmly connected to its sides. The urethra, immediately it

has left the prostate, becomes contracted, and passes through the deep fascia of the perineum, under the arch of the pubes, to the bulb; being in this extent termed the *membranous portion* of the urethra: it is about an inch in length. This portion of the urethra has a posterior internal and an anterior external half: the posterior is situated within the cavity of the pelvis, and is bounded *behind*, by the prostate gland; *before*, by the opening through the fascia; *above*, by the arch of the pubes and anterior ligament of the bladder; *below*, by the rectum; and *laterally*, by those portions of the levater ani muscle which have been termed Wilson's muscles. The anterior half is placed between the deep fascia of the perineum and the bulb which nearly surrounds it, and is therefore situated within the perineum: it is the portion of the urethra which should be cut into in the operation for the stone, or in the operation per perineum for retention of urine. The membranous part of the urethra, in its course from the prostate to the bulb, forms a curve, the convexity of which is turned upwards towards the pubes: it is this curve which frequently renders the passage of an instrument along the urethra into the bladder difficult, but which may be obviated by the surgeon raising the penis to an angle of 45°, at the same time drawing it forward; and, in case of more than usual difficulty, by the finger being introduced into the rectum, so that the point of the instrument may be directed into the bladder.

As soon as the urethra enters the bulb, which forms its third portion, frequently termed the *spongy*, the canal enlarges; but principally in the under part of its circumference, so as to form a kind of sinus here, and is supposed to act as a reservoir for the semen and urine, to be acted upon by the accelerator muscles which immediately surround this part. It is this sinus also which renders the necessity, in passing a catheter, of raising the point of the instrument at this part, to ensure the sweep of it into the bladder. From the bulb the urethra continues, for about seven inches in length, to terminate at the apex of the glans.

The urethra should now be cut open to examine the interior of the canal, particularly the enlargements and contractions which it naturally presents. Its *first* enlargement is in the prostate gland; its *second* enlargement is within the bulb forming the sinus Morgagni; and the *third* is within the glans, which is termed the fossa navicularis. Its *first* contraction commences at the membranous portion of the urethra, and continues until it enters the bulb; the *next* contraction is when the urethra enters the glans; and the *third* is at the orifice of the urethra, and which is sometimes so contracted as to require enlargement before an instrument can be introduced; which, when once beyond this obstruction, readily passes into the bladder. *(Vide diagram, pl. 5.)*

Organization of the urethra.—The urethra is formed of a mucous membrane, connected with the surrounding spongy body by a dense cellular tissue: it is continuous with the mucous membrane which covers the glans penis and prepuce, anteriorly; and with the lining membrane of the bladder, and excretory ducts, posteriorly. The urethra is of a pale white color, excepting at its orifice, where it is a vivid red. It is furnished with numerous lacunæ, which are directed obliquely from behind to before, presenting their openings towards the orifice of the urethra: one large one, called the lacuna magna, is placed within the glans and upon the upper surface of the urethra. From each of these lacunæ a projecting column extends, from before backwards; and there is a tendency to the formation of a middle raphé, towards which the columns converge. This raphé is particularly apparent in a line extending from the lacunæ magna along the upper surface of the canal.

At the under part of the urethra, just at the commencement of the membranous portion, is a prominent oblong body, termed the caput gallinaginis or veru montanum; from which extends a projecting elevation through the whole of the membranous portion, and more or less marking the inferior surface of the urethra with a raphé, similar to that just noticed in the upper surface. On either side of the veru

montanum, the common duct of the vesiculæ seminales and vasa deferentia enter. On the upper surface of the projection is often an opening, or blind pouch: hence called *foramen cæcum* or *sinus pocularis,* from its having been compared to a cup. It has been supposed to be formed for the purpose of protecting the seminal ducts from the entrance of the urine; which, in flowing through the urethra, presses upon the orifice of their ducts. It does not always exist, and is considered by some to be merely a large lacuna.

On each side of the veru montanum is a smooth surface, on which the ducts from the prostate gland open, pouring out their secretion, which, with the semen, is directed on either side of the elevated ridge, extending along the membranous portion of the urethra to the enlarged cavity in the bulb.

It is by many considered that the urethra possesses muscular power; and that muscular fibres are to be met with, passing in a longitudinal direction, very short in their course, interlaced and united at their origin and extremities, and lying between the inner membrane of the urethra and the corpus spongiosum, and being most abundant towards the glans. That the urethra possesses a power of contraction, independent of any disease, is evident from the occasional grasping it exerts in the passage of a bougie; but I should rather attribute it to a power resident in the membrane, than to the contraction of muscular fibres.

As I have before mentioned the double office of the penis, both in procreation and micturition, it is necessary now to mention the circumstances attendant on erection; for this purpose we must describe the course of the circulation of the blood in the penis.

The *arteries* are derived from the internal pudic, which sends off four distinct branches to this organ: one to each corpus cavernosum, and two to the bulb to ramify in the corpus spongiosum.

In the corpora cavernosa it is supposed that the arteries pour their blood into the cells of the part, from which cells the *veins* arise; while in the corpus spongiosum and glans,

the arteries are believed to terminate in the veins, which form a plexus of convoluted vessels, frequently uniting, and producing, therefore, a retardation of the flow of blood. The blood is returned from the penis by large dorsal veins, which usually at the root form one large vein, termed the vena magna ipsius penis, which finally empties itself in the internal iliac vein. From this peculiar course of circulation we may observe, that the blood brought by four arteries, and returned only by one vein, must necessarily distend the organ; particularly when the arteries are excited to inordinate action by the powerful stimulus of the mind. It has been supposed, that the erection of the penis is further maintained by the pressure of the vena magna against the arch of the pubes; but if this mechanical pressure were the cause, how could the penis regain its flaccid state, since the blood has no other outlet? It is therefore rather to be attributed to the cessation of the stimulus of the mind.

The *nerves* of the penis are derived from the lumbo-sacral plexus; the *absorbents* of the penis take a superficial and deep course: the former terminate in the inguinal, and the latter in the hypogastric glands.

This finishes the account of the situation and structure of the organs contained within the cavity of the abdomen; and it must necessarily be observed, that these three classes, namely, the organs of digestion, the organs for the secretion and excretion of urine, as well as those of generation, are all more or less connected with the cavity of the pelvis: hence, therefore, arises the propriety of dwelling yet upon the precise relative situation these several organs maintain, with respect to each other, in the construction of this cavity and its contents.

Before quitting the subject of the pelvic viscera, it will be proper to notice those organs and structures so frequently involved in such diseases as fall more immediatly under the consideration of the surgeon. We know that from various causes,—and from none perhaps more frequently than from indigestion,—that the urine, that complicated secretion,

frequently deviates more or less from its natural composition, so as to undergo changes, giving rise to the most urgent symptons. These changes may consist of various substances, eliminated by the kidneys from the circulation, and passed off with the urine in solution; or they may consist of new combinations of the substances eliminated; giving rise to various calculous formations, which are met with in the calices and pelvis of the kidney, in the ureter, in the bladder, and in the urethra.

Calculi in the kidney.—In this situation they give rise to symptoms of nephritis, and not unfrequently lead to extensive abscesses, and sometimes to the complete destruction of the organ. These complaints are indicated by pain, usually of a lancinating, but occasionally of a dull character, in the region of the loins: which is increased by some, and diminished by other positions of the body; sometimes coming on suddenly, and as suddenly leaving; at others, extending down the course of the ureter to the bladder, or even to the groin and thigh of the side affected; together with numbness of the thigh, and retraction of the testicle. The patient is often affected, especially during the continuance of the pain, with irritability and sickness of the stomach; and rigors are not unfrequently felt when the disease has proceeded to suppuration, indicated by the pain becoming of a dull, heavy and throbbing character, and by pus mixed with the urine, which becomes scanty in quantity. In such cases the surgeon will rarely be called upon to interfere by operation; there are, however, exceptions to this: as for instance, when the pus, instead of finding a free exit with the urine, occasions ulceration, which tends towards the surface, and requires to be evacuated. It frequently happens, in long protracted cases of calculi in the kidneys producing suppression of the secretion of urine, that the patient dies from serous apoplexy.

Calculi in the ureter.—Is indicated by the seat of the pain in the course of the ureter, and its occurring more particularly in sudden and violent spasms; there is frequently, however, great obscurity in detecting the stone in the ureter,

in consequence of the symptoms accompanying it, being precisely similar to those of stone in the kidney: such as pain and irritation in the course of the canal, pain in the loins, numbness of the thigh, retraction of the testicle, pain in the groin, nausea, vomiting, and suppression of urine. One of the clearest diagnostic marks is, the shifting of the pain as the calculus changes its position in its progress along the ureter. It does, however, sometimes happen, that calculi pass along the whole length of the ureter into the bladder, without having occasioned a symptom from which their presence could have been suspected. Cases are on record of calculi having become fixed near the termination of the ureter, when they have been felt by examination per anum; and Le Dran mentions a case in which a calculus partly protruded into the bladder from the ureter, where it was so firmly fixed, that he was prevented from removing it by operation; but by a second operation he succeeded in its extraction, from the parts which enclosed it being ulcerated.

Calculi in the bladder.—It is when calculi lodge within the bladder, that the case becomes one of the greatest surgical importance. In this situation they may either be first formed from the precipitation of earthy matters contained in the urine; or they may enter from the ureter, and become a nucleus for further depositions. There are other causes occasionally furnishing nuclei to the deposition of calculous matter; such as the accidental presence of foreign bodies, a small coagulum of blood, or any tenaceous or albuminous matter, at first collecting a loose aggregation of earthy particles, which subsequently may form a more compact and solid mass. From each of these circumstances symptoms, sooner or later, occur of the most distressing kind, and which can alone be removed by the performance of a formidable operation. The stone, while yet very small, produces generally but little irritation, but now and then it has a tendency to obstruct the free passage of the urine, by its being forced against the orifice of the urethra; hence an irregular flow of urine is one of the earliest symptoms: at the same time,

upon the expulsion of the last portions of the urine, the contraction of the bladder directs the calculus towards the neck of the organ, and gives rise to the sympathetic pain so commonly felt at the extremity of the penis. Occasionally, small calculi will either pass through the urethra without occasioning inconvenience, or they may be lodged in the narrow parts of the canal, so as to occasion the necessity of their being removed by excision.

When calculi increase in size, they occasion symptoms of a more formidable character, especially in constitutions naturally irritable. The bladder will become irritable and inflamed, and will secrete an excessive quantity of mucus, accompanied with frequent desire to void the urine, from the irritation of that secretion upon the morbidly sensitive surface of the bladder. The irritation of the calculus will be felt most severely as the bladder becomes nearly empty, when its contractions upon the calculus give rise to renewed efforts, increased desire, and often total inability to void the remaining portion of urine.

The calculus, when large, will press upon the rectum, exciting tenesmus, and a sense of bearing down, with frequent and fruitless attempts to pass a stool. Frequently, also, the urine will be loaded with mucus, albuminous matter, or purulent discharges mixed with blood.

The coats of the bladder will become remarkably thickened, its capacity diminished, and at length the patient sinks exhausted by pain and suffering.

In certain instances, the bladder will sustain the presence of stones of considerable magnitude for many years, with comparatively trifling inconvenience.

The symptoms occasioned by calculi in the bladder are most obvious, when the stone lies in the neck; but they vary with the different situations in which the stone may be placed. Also great difference arises from the species of calculi contained in the bladder; and although it has been supposed that the mulberry calculus is the most painful, from its irregular surface; it must, however, be observed, that

calculi of the tripple phosphates, occasion by far the greatest degree of irritation. This is probably attributable more to the irritability of constitutions prone to these formations, rather than to the physical or chemical properties of the concretions themselves.

The sound, in general, enables the surgeon to ascertain not only the presence, but the situation of a stone. Occasionally, however, it will be necessary to vary the position of the body; and I have witnessed instances, when the most expert have failed in finding the calculus, a surgeon of much less experience has touched it on the first attempt. Such cases occur when the bladder is flaccid, and the stone small.

In cases where a stone is enclosed in a sacculus of the bladder, or when adhesion to an ulcerated surface has taken place, the greatest difficulties arise; and it may so happen, that a stone easily discovered at one time, may not be so at another, in consequence of the contraction of the bladder being greater in one part than at others, forming a partially flaccid pouch, into which the stone falls, and for a time will be obscured. This accident occurs mostly in the upper region of the bladder; here the muscular fibres, particularly when the viscus is much thickened, may be observed to form a pointed pouch, from the apex of which they arise, diverging more or less as from a point or fulcrum. A stone lodged in this situation, may be firmly grasped for an hour before the contraction yields.

In certain instances, the administration of alkaline medicines will lessen the irritable state of the bladder, and consequently the degree of pain, so much, as to lead to the supposition that the stone had been dissolved: also, the bladder may contain cysts, into which the stone falls, giving rise to some of the reputed cases of their solution from alkaline remedies: it appears, however, that when a stone has once formed within the bladder, it cannot be removed by the agency of any chemical medicine.

Affections of the prostate gland are occasionally mistaken

for symptoms of stone in the bladder; they are distinguished by the greater uniformity of the pain, less subject to aggravation from exercise, and are rendered clearly obvious when they can be detected by an examination per rectum. Calculi passing from the prostate gland, are so similar to lithic calculi in their appearance, that they require a chemical examination to ascertain their distinct nature; when it will be found, they are composed of phosphate of lime, and not of lithic acid: hence the necessity, in cases of doubt, of chemical analysis regulating the treatment; it having happened, that stone in the bladder has been treated for prostate calculi, and *vice versa.*

Of the various Deposits forming Urinary Calculi.

Calculi are composed of the same ingredients in the kidney, the ureter, the bladder, and the urethra; although certain combinations are more frequent in some situations than in others.

They are various in size, from minute angular crystals called gravel, to substances nearly filling the cavity of the bladder. One of the largest in the human body was taken from the bladder of Sir David Ogilbie, weighing forty-four ounces, of an elliptical form, the long axis sixteen, the short axis fourteen inches; and is preserved in the museum of the College of Surgeons.

Their form is various: in the bladder, when single, they are generally spherical; when more than one, they present flattened sides from pressure—or they may be oblong, flat on both sides, or circular—with smooth or rough surfaces. In the kidney, they conform to the shape of the pelvis and infundibula: in the ureter, they are generally oval.

They vary also in hardness and color: in hardness, from that of marble to a loose consistence easily broken to pieces; in color, from a chalky whiteness to a slate grey, or to a yellow and deep mulberry brown.

Their interior is generally formed of concentric laminæ.

Much interesting matter has been elicited from the chemical analyses of urinary calculi, relative to their formation and composition. The medical profession are principally indebted, after the important discovery of uric acid by Scheele in 1776, to the labors of Dr. Wollaston, who first discovered the nature of gouty concretions, the fusible calculus, the mulberry calculus, the cystic oxyd and calculus of the prostate; and although these discoveries were published in the philosophical transactions, at various periods, yet they were subsequently claimed by the celebrated French chemist, Fourcroy, both in his memoir in the *Annales de Chimie,* and in his *Systeme des Connoissances Chimiques.*

The collection of calculi made by Mr. Lucas during his practice in Guy's Hospital, increased by his son and successor, and presented to the museum for the benefit of the school, together with the numerous additions made by Sir Astley Cooper and others, most of which have been carefully analyzed by Dr. Marcet, and labelled according to their chemical composition, and since his time by Dr. Benjamin Babington, present an ample source of information, well worth the attention of those who are desirous of investigating this subject.

The component parts of urinary calculi hitherto detected; are lithic or uric acid, phosphate of lime, ammoniaco-magnesian phosphate, oxalate of lime, cystic oxyd, and a variable proportion of animal matter. Whenever either of the earthy matters predominate it generally imparts a peculiar character to the calculus, whence they have been classed under the following heads:—

1. Lithic calculus—consisting chiefly of lithic acid.
2. Bone earth calculus—consisting chiefly of phosphate of lime.
3. Triple phosphate calculus—consisting chiefly of ammoniaco-magnesian phosphate.
4. Fusible calculus—consisting chiefly of the two former.
5. Mulberry calculus—consisting chiefly of oxalate of lime.
6. Cystic oxyd calculus—consisting chiefly of cystic oxyd.

7. Alternating ealeulus—eonsisting of two or more of the above, in alternate coneentric layers.
8. Compound ealeulus—eonsisting of various proportions of two or more of the above ingredients, so intimately mixed as not to be separable exeepting by chemieal analysis.

With the above may be added—

9. Calculus of the prostate gland—eonsisting of phosphate of lime, not distincly stratified, and tinged with the seeretion of the prostate.

The varieties of ealeuli are generally distinguished by their physieal properties; but as they are frequently of diffe-rent natures, they must be sawn through to aseertain the different strata in whieh they may be formed. A very few tests, of a simple nature, are all that are necessary to aseer-tain their general ehemieal eomposition, an enumeration of whieh would lead me too far from the professed objeet of my leetures. The able essay of Dr. Marcet on ealeulous disor-ders, eoupled with the valuable eontents of the museum, forms an ample souree of information on this subjeet; I shall, therefore, simply note the general physieal properties of eaeh species of ealeulus, by whieh they may be distinguished from each other in most instanees.

The *lithic acid calculus* is of a reddish brown or fawn eolor, hard, inodorous, of an ovoid form, sometimes much flattened, smooth or studded with minute tubereles: inter-nally they are disposed of eoncentric laminæ, of a erystalline texture, not unlike the seetion of a pieee of mahogany. Oeeasionally they vary from a fawn to a light grey or elay eolor, whieh is in proportion to the admixture of lithate of ammonia and the phosphates.

Phosphate of lime, or the *bone earth calculus*, is of a pale brown eolor, of a smooth surfaee as if polished. Inter-nally it is disposed in laminæ easily separable from eaeh other; oceasionally the laminæ are striated in a direetion perpendieular to the surfaee.

The *triple calculus*, or *ammoniaco-magnesian phosphate*,

is whiter and more compact than the phosphate of lime; it is not laminated, and is easily reduced to powder; its surface is uneven, and is commonly covered with minute shining crystals, which also are found between the interstices of other calculous laminæ; indeed, it never forms the whole substance of a calculus, and is more obvious from its partial depositions.

The *fusible calculus* is whiter than any other species, frequently resembling a mass of chalk. Internally they are disposed in laminæ, some of which are frequently separated by layers of the shining crystals of the triple calculus: in other instances it is of a spongy texture, in which the laminæ are not discernable. They are often of a large size, and moulded to the form of the cavity of the bladder.

The *mulberry calculus,* or *oxalate of lime,* is very hard, of a dark brown color, of a rough tuberculated surface, whence its name from its resemblance to a mulberry: its internal structure is imperfectly laminated. Occasionally this calculus is smooth and pale colored, so as to resemble the hue and smoothness of hemp seed; whence it has been supposed that the red color is owing to blood from hæmorrhage in irritation. It must be remarked, however, that the greatest irritation arises from the triple phosphate, and not from the mulberry calculus.

The *cystic oxyd calculus* resembles the triple phosphate of magnesia more than any other calculus; but they are more compact, and not disposed in distinct laminæ, but in a confusedly crystallized mass throughout. It is of a yellowish white color, semi-transparent, resembling wax, of a smooth surface. It was named by Dr. Wollaston cystic oxyd, from its combining readily with acids and alkalies, and from its being found only in the bladder in the two instances in which he had obtained specimens of it; it has, however, since been obtained distinctly from the kidney by Dr. Marcet.

Alternating calculus.—The alternating calculus may be composed of various species in concentric layers. A specimen, figured by Dr. Marcet (*p.*18, *fig.* 8), exhibits a nucleus

of lithic acid, upon which is a layer of bone earth, over which is another of oxalate of lime, and lastly the fusible calculus forms the exterior. Oxalate of lime and lithic calculi frequently alternate; also lithic strata with the phosphates; sometimes the mulberry alternates with the phosphates.

Compound calculi are more easily detected by their confused chemical analysis than by a peculiar external character: they are hard, more or less irregular, and scarcely, if at all stratified. They have no one feature by which they may be distinctly referred to either of the other species. They are of comparatively rare occurrence.

Calculus of the prostate gland are often mistaken for stones in the bladder; they are similar to lithic concretions; they vary from the size of a pin's head to that of a hazel-nut; they are more or less spheroidal, of a yellowish brown color; and all that have yet been chemically examined, according to Dr. Wollaston, consist of phosphate of lime.

When the symptoms which are occasioned by the presence of a stone have become urgent, they can only be removed by the operation of lithotomy. This operation is not in any instance warrantable, however urgent the symptoms, unless the calculus can be actually felt and heard by the process of sounding; and even then it is not, in every instance, proper for the surgeon to perform the operation, until he has examined the state of health of the patient, the probable existence of calculi in the kidney or ureter, and the presence of any organic disease which may render the result of the operation more dangerous. The most unfavorable indications arise from the presence of diseased lungs, diseased liver, albuminous urine, and such protracted diseases as have a tendency to diminish vital power.

The next consideration is the previous preparation which the patient should undergo, and for which no general plan can be adopted, as it must in every instance be regulated by individual constitution. In plethoric habits, it may be necessary to use depletion, for which blood-letting and purging

are advisable; and I have found them more efficacious when conjointly employed than when purging alone has been resorted to. It is requisite also to analyze the urine, in order to regulate the medical treatment: when the acid qualities preponderate, alkaline medicines are most proper; when calcareous or magnesian salts prevail, the acids, particularly muriatic, should be administered: the object of which is, to prevent as much as possible the further deposition of calculous matter. I consider it also of great importance to prepare the patient's mind, as well as his body, for what he has to undergo: and for this purpose it is necessary to speak to him of the position in which he will be placed, and to teach him to grasp firmly the soles of his feet for short periods of time; in order in some measure to accustom him to what otherwise, at the time of operation, very generally causes the greatest terror and increased excitement. The night previous to the operation, a purgative should be administered to clear the alimentary canal; and the following morning an enema, for the purpose of securing a complete evacuation of the rectum. In very irritable habits it is also advisable, about two hours before the operation, to throw up about thirty drops of tinc. opii in an ounce of thick gruel, which materially lessens not only the muscular irritability of the parts, but produces a sedative effect, the benefit of which continues even after the operation. The surgeon should himself ascertain that every thing necessary to the operation is fully prepared before the period appointed, in order that the patient's mind may not be kept in agitation from unnecessary delay.

The patient being placed in a proper position, and secured in the usual manner, a staff is to be passed into the bladder; and the presence of the stone being ascertained, the staff is given to an assistant to hold with his right hand, standing on the left side of the patient. The surgeon then commences the operation as follows; remembering, however, that its progress consists of distinct and separate steps or stages; to each of which he should confine his mind during its

progress, in order to meet the difficulties it may separately present, and not alone to the ultimate result of the extraction of the stone from the bladder.

First step—consists of an incision through the integuments and superficial fascia of the perineum, which should be regulated by the depth and breadth of the parts in each individual. This incision should commence on the left side of the perineum, in the centre of an imaginary line, drawn horizontally from the point of junction of the raphé of the perineum with that of the scrotum, to the ramus of the pubes; and should be continued obliquely downwards to the centre of a similar line, drawn from the centre of the verge of the anus to the tuberosity of the ischium. The degree of obliquity of this line depends upon the distance between the tuberosities of the ischia. In this step the following circumstances may occur: the superficial arteries of the perineum may be so much enlarged as to produce a troublesome hæmorrhage, leading to the necessity of a ligature: a fistulous abscess may possibly be laid open, or a perineal hernia be cut into; each of which occurrences point out the necessity of previous minute examination. By this incision a triangular space is laid open: bounded above, by the membranous part of the urethra; below, by the transverse muscle and artery of the perineum; on the inner side, by the accelerator urinæ; and on the outer, by the erector penis.

Second step—consists of an incision through the deep fascia of the perineum, which lays open the cavity of the pelvis. In order to effect this, the surgeon passes the fore finger of his left hand to the membranous portion of the urethra, between the bulb and triangular ligament of the pubes; by which he is enabled to direct his knife through the urethra into the groove of the staff, and from thence he continues the incision in the direction of that first made, through the deep fascia of the perineum, the fibres of the transversus perinei alter muscle, the transversus perinei muscle and artery, and some of the fibres of the accelerator urinæ.

In this step of the operation, the principal point to be observed is the opening of the urethra, which should always be made in the membranous portion: in doing which, the bulb should be carefully avoided; not only on account of its large artery, but because from the membranous portion of the urethra there is a straight passage to the bladder. It is in this incision that the surgeon may wound the rectum, which is avoided by the oblique direction of the incision towards the tuberosity of the ischium. Many surgeons defer the opening of the urethra, until the third step of the operation; but I prefer commencing the second step as above directed: first, because it is the best and most precise point whereat to commence the second incision; and, secondly, in so doing the complete division of the deep fascia of the perineum is secured; a portion of which is otherwise liable to be left as a bridle undivided, and requiring an incision for the removal of the impediment. Notwithstanding every precaution, the artery of the bulb is occasionally wounded; which, from the depth of its situation and its retraction behind the deep fascia of the perineum, cannot, under any circumstances, be secured without considerable difficulty. When this accident occurs, much time should not be lost in fruitless attempts to secure this artery, but the operation should be prosecuted; and then, by pressure, the bleeding vessel may be stopped. Should the transverse artery of the perineum, which must be necessarily divided in this step, be so large as to occasion a troublesome hæmorrhage, it may be readily tied from its superficial situation.

Third step—consists of the division of the whole length of the membranous portion of the urethra, of the prostate gland, and of the neck of the bladder. This object is effected by fixing the point of your knife in the groove of the staff, by the opening already made in the membranous portion of the urethra, at the commencement of the second step. Having clearly ascertained that the point of the knife is *in the groove of the staff without any interposing substance*, the surgeon takes the staff from his assistant with his left

hand, and depresses its handle, until he brings it parallel with the axis of the pelvis, in which position it presents a direct passage for the knife into the bladder *(Vide diagram III. pl. 3.)*: and in order that this may be effected in the safest manner, before the knife is passed into the bladder, the groove of the staff and the edge of the knife should be simultaneously lateralized, or directed to the left side of the patient, at such an angle as will bring this incision in a direction corresponding to the two already made. If the gorget instead of the knife should be used to make this section, its cutting edge should in a like manner be laterally directed. In passing the knife as here described, the surgeon has the option of regulating the size of the opening, either on its entrance into the bladder, by the angle at which he holds it with the staff, or by the power which he has of enlarging the opening as he withdraws the knife; whereas, with the gorget, the opening must depend entirely upon the size of the instrument, and must be made when thrust forward into the bladder. The parts divided in this section besides the urethra, prostate gland, and neck of the bladder, are the fibres of Wilson's muscle on the left side of the urethra, and occasionally some few fibres of the levator ani, when the section of the prostate gland is complete.

The principal point to be attended to in this section is the angle at which the knife is held in the division of the prostate: if too much lateralized, the internal pudic artery is endangered; if too much in a perpendicular direction, the ducts of the vesiculæ seminales, vasa deferentia, and rectum may be wounded; while they may be avoided by the knife being directed in the course of the incisions of the two first steps, namely, midway between the verge of the anus and the tuberosity of the ischium.

If the pudic artery be wounded, no hopes can be entertained of securing it with a ligature; the best mode therefore to be adopted is, to pass a canula into the bladder, surrounding it with a firm compress of lint; by which means, as the urine is allowed to flow, the pressure may be kept for

a sufficient time for the closing of the wounded vessel. The artery of the bulb may also be divided in this step, so near to the pudic as to require similar treatment.

Fourth step—consists of the introduction of the forceps, and removal of the stone from the bladder. When the bladder has been opened, it is indicated by a gush of urine, or the cessation of resistance to the knife on completing the section of the prostate. The surgeon should now take the staff in his right hand, and introduce the fore finger of his left into the bladder, to ascertain the size of the opening he has made, and, if he can, the position of the stone; being satisfied on these points, he withdraws the staff, retaining his finger within the bladder, to direct the introduction of the forceps. If the perineum should be so deep as to prevent the finger from reaching the bladder, it is advisable to use a blunt gorget as a director for the forceps. The forceps should next be introduced with the blades closed, and used as a sound to ascertain the precise position of the stone; which, being ascertained, the blades should be gently separated, in order to grasp it. In effecting this object, numerous difficulties may occur, arising from the position, form, and the size of the stone, in each of which the surgeon's mechanical judgment will be required in the proper choice of forceps suitable to the existing difficulty. Soft and friable calculi frequently crumble to pieces before they can be extracted: in such cases it is necessary to remove any portion capable of being extracted by instruments, and afterwards to inject the bladder freely with tepid water. In the extraction of the stone, too much stress cannot be laid upon the necessity of *gentleness* in the various manipulations which may be necessary; and the force which is sometimes required in the extraction of large calculi should be used not only cautiously but gradually, in order that the parts may yield to the passage of the stone, and not be unnecessarily lacerated.

Immediately the stone has been removed, and the surgeon has ascertained that no other may yet remain in the bladder, the patient should be released from his painful position, by

the removal of the bandages which confined him: he should not, however, be conveyed to his bed until the hæmorrhage has ceased: which, in elderly people, frequently continues some time after the operation, from the enlargement of the veins about the prostate and neck of the bladder. When placed in his bed, the thighs and trunk should be bent upon the pelvis, so as to relax the abdominal muscles. I do not consider it advisable, as is frequently recommended, to tie the knees together, as it tends to direct any hæmorrhage which may occur into the bladder, where it may accumulate unperceived to a dangerous extent; or, at any rate, will become a source of great irritation, producing rigors and other dangerous symptoms, which will continue until the bladder expels it by its own efforts. The after treatment can hardly be generally considered, but must depend upon the constitutional and local symptoms occurring in each individual case.

I have refrained from mentioning the various instruments which are adopted by different surgeons in the performance of this operation, as I believe it a secondary consideration whether the gorget, the knife, or the bistourie cachet be used to cut into the bladder, so that the instrument be directed by the hand of a skilful operator.

I cannot, however, dismiss this subject, without adverting to the instruments invented and adopted by my colleague, Mr. Aston Key; but as he has published so full an account of them in his treatise on lithotomy, it is needless for me to say more of them here: yet in justice to Mr. Key, and in consonance with my own feelings, I must express my admiration of their complete efficacy, and of the great skill I have so frequently witnessed in his practical application of them at Guy's Hospital.

The operation for puncturing the bladder in cases of retention of urine, through the perineum, is performed much in the same manner as the operation for the stone; the great distinctions being, that in the former the incision is made in the course of the raphé; and on the membranous

portion of the urethra being opened, a canula only, and not a cutting instrument, is passed into the bladder.

Practical Remarks.

The testicle, in common with the rest of the human body, is liable to various diseases, which, from the complication of its structure and importance of its function, are of great moment in a surgical point of view.

Inflammation of the testicle, which is known by the name of hernia humoralis, but which Sir Astley Cooper in his late work on this subject has much more properly named testitis, is one of the most common diseases incident to this organ. It may arise from various causes; assuming either an acute or chronic, a specific or malignant form, depending upon a peculiar constitution or specific action. This work will not admit of a minute detail of so voluminous a subject; I shall therefore merely advert to some of the diseases, concerning which the surgeon is most frequently consulted.

Acute testitis most frequently arises from suppression of gonorrhœa, and may be known by swelling, redness, and pain of the scrotum, with a sense of weight of the testicle, and a dull obtuse pain, as if the part were squeezed. The pain extends along the spermatic cord to the groin, hip and loins, often producing sickness, vomiting, pains in the bowels, and obstinate constipation. Sometimes the neck of the bladder will be affected, accompanied by much constitutional fever.

Inflammation of this character seldom or never goes on to suppuration; but should it arise from a blow, or other injury, and not from a sympathetic action, then matter more frequently forms: the symptoms above enumerated are then much aggravated, and are accompanied, in addition, with severe rigors. This disease has been mistaken for hernia. When in an acute form, it has produced a swelling in the spermatic cord, vomiting and costiveness. The resemblance is greatest to a congenital hernia, as the intestine may be then in contact with the testicle, otherwise the distinct situation of the testicle forms a simple diagnostic mark. The general history of the case, however, usually enables the surgeon to form a just diagnosis; but should there be a combination of circumstances, causing a continuance of the suspicion of the existence of hernia, a purgative enema, and the operation of an active aperient, would remove the existing doubts.

The treatment of testitis, when arising from suppressed gonorrhœa, is by fomentations to restore the discharge from the urethra; local bleeding by leeches, should be immediately had recourse to; but if they fail in reducing the inflammation, cupping the loins has a most decided beneficial effect: the bowels should be freely opened, the patient

kept in a recumbent posture, and the scrotum completely supported by a cloth, kept constantly moistened by an evaporating lotion, containing the muriate of ammonia. When there is a great tendency to the recurrence of these attacks, calomel and opium are the most beneficial remedies for its removal, and may occasionally be assisted by the introduction of a bougie armed with caustic alkali.

Acute inflammation may lead to the formation of abscess in the testicle, or to a permanent disorganization of its substance. Specific inflammation may lead to an hydatid state of the testicle; and inflammation in constitutions of a malignant diathesis, may tend to the formation of scirrhus and fungus hæmatodes: in either of which cases, the removal of the organ may be required.

In the recent elaborate work upon the testis by Sir Astley Cooper, so full a treatise is given of these diseases, that I feel I cannot do better than refer my readers to his work upon that subject.

When circumstances render the operation of castration necessary, the spermatic cord is first to be secured by making an incision from the external ring downwards upon the scrotum for about two inches, and passing a needle armed with a ligature between the blood-vessels and vas deferens, the cord is to be divided below it; then drawing the retracting cord forwards with the ligature, the spermatic and artery of the vas deferens are to be secured. The surgeon then grasps the diseased testicle, and its enclosing scrotum, in his left hand, while an assistant takes the healthy testicle in a like manner, drawing it with the septum, as far as the parts will allow, from the diseased side; the surgeon then, with one sweep of the knife, removes the diseased testicle, and its enveloping scrotum. The bleeding vessels should then be secured, but the parts not dressed until a sufficient time has elapsed to secure the patient from the recurrence of hæmorrhage.

The advantage of this mode of operation, is the shortness of its duration, and the effectual prevention of the formation of troublesome abscesses, which so frequently occur when the bag of superabundant scrotum is left.

In the last operation which I performed in this manner, the wound was healed in about ten days. When the disease has produced great enlargement of the testicle, and adhesions exist to the septum scroti, great caution is required, as the septum should if possible be left entire.

A collection of water between the two layers of the tunica vaginalis, termed hydrocele, frequently leads to the necessity of an operation, for the purpose of merely evacuating the fluid, which is designated the palliative cure; or for injecting the cavity after the fluid has been drawn off, when the radical cure is intended.

It is necessary first clearly to ascertain the existence of fluid, from its

semi-transparency when examined, by placing a candle on one side of the tumour, in a darkened room. The operation now generally adopted consists of a puncture with a small trocar and canula. The surgeon grasps the scrotum with his left hand, so as to secure the testicle in the back part of the scrotum, while the fluid is made to occupy the fore part. The trocar and canula having been well oiled, the point of the instrument is to be introduced with a firm but sudden force into the tunica vaginalis, at the point where the convexity of the tumour renders the testicle most distant. On the water being drawn off, the palliative cure is complete: but should the radical be intended, the surgeon should now examine the state of the testicle, which, if free from disease, he performs, by injecting into the tunica vaginalis, with an Indian-rubber bottle having a brass stop-cock exactly fitted to the canula, an injection composed of equal parts of port-wine and water, and in quantity equal to two-thirds of the fluid which has been withdrawn, and which should be secured by the stop-cock. This injection should generally be allowed to remain in the tunic five minutes; regulated, however, by the pain and irritability of the individual. It is not the expression of pain in the part, which is to induce the surgeon to withdraw the fluid; but the occurrence of the pain along the cord, and in the loins, causing nausea and sickness, which indicates the proper period to remove the injection,—which is done by turning the stop-cock, and allowing the fluid to escape through the canula.

Two circumstances are to be particularly attended to in the performance of this operation: first, to avoid injury to the testicle; and secondly, to secure the entrance of the injection into the tunica vaginalis, by thrusting the canula its whole length into the tunic at the time the trocar is withdrawn; for should the injection be forced into the cellular membrane, the scrotum will necessarily slough. When such an accident unfortunately does occur, the surgeon should make several incisions into the scrotum to evacuate the fluid, and foment the parts to allay inflammation.

The after treatment depends upon the degree of excitement produced by the above means: should irritation run very high, antiphlogistic remedies, and the recumbent posture, should be had recourse to; but if, on the contrary, there should not be a sufficient degree of pain which the surgeon considers necessary for the cure, the patient should be allowed to walk about; and even, in some cases, must have stimulants to induce inflammation. Although this is termed a radical cure, it does not invariably succeed, even under a repetition of the operation.

The old operations by caustics, setons, and incision, have all given way to the above improved mode; which was first recommended by Sir James Earle. Severe blows on the scrotum do sometimes produce

an immediate swelling of the part, attended with more or less pain, depending upon the degree of injury the testicle has sustained. Sometimes leeches and the application of evaporating lotions, with a general antiphlogistic treatment, will remove these effects; but, at others, a swelling of a pyramidal form will still remain, which fluctuates to the touch, is free from pain, and, in fact, offers all the diagnostic appearances of hydrocele, excepting its transparency. This disease, named hæmatocele, is produced by an effusion of blood instead of serum, and is to be cured by a free incision into the tunica vaginalis to evacuate the extravasated semi-coagulated blood. Some surgeons have recommended that flour, or any harmless substance, should be introduced into the tunica vaginalis, to secure the obliteration of the cavity by adhesion; but I consider this practice as highly dangerous, and a remedy that is worse than the disease.

Female Organs of Generation.

The genital organs in the female are as complicated in their structure, and as various in their uses, as those of the male: they may be divided, in the same manner, into the *external* and *internal* organs of generation. Physiologically considered, they may be arranged into those which serve for copulation, those for conception, and lastly, those which contribute to the nourishment of the offspring after birth.

The external organs combine the first and third classes; while the internal are not only essential to conception, but also to the maintenance and growth of the fœtus for a determinate period.

The external organs, or those for copulation, comprehend several parts differing in their structure, use, and name; and should, therefore, be individually considered.

The *vulva* or pudendum, is the term given to all the genital organs in the female, which are perceptible externally; it forms, in fact, the entrance to the vagina, and is bounded, above, by the *mons veneris;* behind and below, by the *perineum;* and laterally, by the *labia:* for the examination of these structures, no dissection whatever is necessary.

The *mons veneris,* constitutes the soft cushion of fat which is placed upon the female pubes, furnished, at the age of puberty, with a considerable quantity of hair: there is

nothing particular in reference to the structure of this part, unless we observe the density of the cellular membrane, which forms a series of tendinous bands.

The *labia pudendi*, extend downwards from the mons veneris as membranous folds, on either side the entrance of the vagina, gradually becoming thinner as they descend towards the perineum, where they unite and form a junction termed the *fourchette* or *frænulum pudendi*. The interval or rima between the labia, is of an elliptical form, produced by their inner surface which is lined by mucous membrane, while their external surface is continuous with the skin of the thighs, and is furnished with a number of hairs, and sebaceous follicles. The edges of the labia are thin and convex; their substance is made up of fat, and white strong bands of a tendinous structure, with fibres of the constrictor vaginæ muscle; vessels and nerves also enter into their composition.

The labia should now be separated, in order to expose the interior of the vulva, in which will be found the following parts; at the upper part, immediately below the diverging of the labia from the mons veneris, the *clitoris* is seen; from either side of which proceed projecting membranous folds, termed the *nymphæ* or lesser labia, which diverge inferiorly to embrace the entrance of the vagina, between which and the union of the greater labia, at the fourchette, is a space termed the *fossa navicularis;* thus much may be observed on separating the greater labia: the nymphæ should be now separated to expose the *meatus urinarius*, which is placed rather less than an inch below the clitoris. Between the meatus urinarius and the opening of the vagina, is a space termed the *vestibule*.

The *clitoris*, is a small elongated body, placed beneath the upper commissure of the labia, by which it is usually hidden; excepting when greatly developed it will project beyond them. It is composed of cellular structure, similar to the corpora cavernosa of the penis, and in the same manner is attached by two crura to the rami of the ischia, and to the pubes by a suspensory ligament. The free extremity

of the clitoris terminates in a rounded imperforated extremity, somewhat resembling the glans penis, and is surrounded by a fold of mucous membrane, which is continuous with the nymphæ, but bears an analogy to the prepuce. The structure of the corpora cavernosa of the clitoris is similar to that of the penis, but appears comparatively rather more compact and dense.

It is furnished with branches from the internal pudic artery, and with filaments from the internal pudic nerve—larger in proportion to the size of the organ than in the male.

The *nymphæ, labia minora,* or *labia interna*—are two projecting duplicatures, extending from either side of the rounded extremity of the clitoris, as a ridge or fold of mucous membrane; and passing downwards, are lost on the inner side of each external labium, and about the middle of the opening of the vagina. They are thicker in their centre than at their extremities, and are composed of a spongy tissue, in which numerous blood-vessels ramify, giving them erectile power. This structure is covered by a reflection of the mucous membrane of the vulva.

On separating the nymphæ, the clitoris will be seen to form the upper commissure; about an inch below and posterior to which, is situated

The *meatus urinarius.*—This orifice presents a projecting rim, most prominent at the lower part, and is produced by a duplicature of the mucous membrane of the vulva. It is by this projecting rim that the surgeon is enabled to pass a catheter, without exposing the parts. The meatus urinarius is not more than one inch and a half in length, but much larger than the urethra of the male: its direction is slightly curved beneath the arch of the pubes, in its course to reach the bladder, presenting its concavity upwards. This passage is so readily dilatable, that calculi of considerable size may be removed from the bladder without the assistance of cutting instruments. The space between the clitoris and the opening of the vagina is termed the vestibule, in the centre of which is placed the meatus urinarius.

At the base of the vestibule is placed the *orifice* of the *vagina;* which, in the virgin state, is generally nearly closed by a portion of mucous membrane in the form of a crescent, the broadest part of which is next to the perineum: this is called the *Hymen;* and, in some instances, so completely closes the orifice of the vagina as to interrupt the flow of the menses. After it has been ruptured, its remains form several small rounded vascular bodies, termed the *carunculæ myrtiformes.*

The labia unite before the perineum in a commissure, named also fourchette or frænulum pudendi; leaving a space between the commissure and the opening of the vagina, termed the *fossa navicularis.*

The whole of these parts, comprehending the vulva, are covered by a mucous membrane, which joins the internal integuments at the free edge of the labia pudendi. It is furnished with an epidermis or cuticular covering, which is gradually lost with the increasing depth of the parts, and with numerous mucous follicles and crypts, particularly around the clitoris and internal surface of the nymphæ.

The examination of the remaining parts of the female organs of generation, is best prosecuted in a side view of the pelvis, which should be prepared in a similar manner to that of the male.

The *vagina* is a membranous passage, from about six to eight inches in length. Its canal is of an oval figure, having its long axis placed laterally. The vagina, in its direction from the vulva to the uterus, is curved, presenting a convexity opposed to the rectum, and a concavity to the bladder and urethra.

In the erect posture the vagina is bounded *above*, by the uterus; and *posteriorly*, by a small portion of peritoneum: *below*, by the vulva; *anteriorly*, by the bladder and meatus urinarius; *posteriorly*, and *inferiorly*, by the rectum and a small portion of the levatores ani; from which, however, it is separated by a mass of cellular tissue, enclosing numerous vessels.

The *uterus* is placed in the middle of the pelvis, between the bladder and the rectum, where it is suspended by its two broad ligaments, *above* the vagina and *beneath* the small intestines. It is a hollow viscus, of an oblong form, about three inches in length in its unimpregnated state: it has an enlarged upper extremity, named its fundus; a narrowed smaller inferior portion, which terminates in the vagina, named its cervix; while the intermediate space is termed its body: besides which it has two corners or angles, two sides, an anterior and a posterior surface, and an orifice to its internal cavity, termed the os tincæ.

The *fundus* is the upper part of the organ, situated above the attachments of the fallopian tubes: it presents a convex superior edge and two lateral angles, to which are attached the fallopian tubes.

The *body* lessens in size as it descends from the fundus to the cervix, presenting an anterior and a posterior slightly convexed surface, and two lateral edges, where the peritoneum from the surfaces forming the broad ligaments are not attached: this space is filled with cellular membrane.

The *cervix* is continued from the body, and terminates in the vagina, which surrounds it: at its junction with the body it is narrowed, but enlarges as it proceeds into the vagina, to terminate in a thickened rounded extremity, in which is a transverse orifice termed the *os uteri* or *tincæ*.

The *broad ligaments* which suspend the uterus, are formed of a duplicature of the peritoneum which passes from the posterior surface of the bladder, to be reflected at the point of junction of the vagina and cervix uteri: they then proceed along the anterior surface of the body of the uterus, around the fundus, to the posterior surface; enclosing in this turn, not only the uterus, but also the fallopian tubes, round ligaments and ovaria: these two layers from the fundus, and from the anterior and posterior surface, as they pass off from the sides of the uterus to the pelvis, complete the broad ligaments. The peritoneum continues to proceed along the posterior surface of the uterus to the posterior surface of the vagina; from which

it is reflected upon the rectum, forming between the two organs a *cul de sac*, as it does between the bladder and rectum in the male.

The *fallopian tubes* are seen enclosed in the upper edge of the broad ligaments, extending laterally from the corners of the fundus of the uterus, four inches in length; being at first straight and small, but at their extremities becoming larger, rather tortuous, and the size of a goose-quill. At their terminations they are fimbriated; one of the fimbriæ being generally larger than the rest, and directed towards the corresponding ovarium.

The *ovaria* are placed one on each side of the uterus. between the two layers of the broad ligaments, below the fallopian tubes, and above the round ligaments; being enclosed in a proper capsule of cellulo-fibrous membrane. They have an oval form, flattened anteriorly and posteriorly. They are in size smaller than the testicles: their outer extremities give attachment to one of the fimbria of the fallopian tubes, their inner to the uterus, by ligamentous cords placed behind and a little below the round ligaments. These cords are named the ligaments of the ovaria.

The *round ligaments* arise from the superior, anterior and lateral parts of the uterus; anterior to, and a little below the attachments of the fallopian tubes. They then take their course to the internal rings, and pass through them into the inguinal canals; then through the external abdominal rings, to be lost in the cellular tissue of the mons veneris, labia pudendi, and groin.

Before removing the parts of generation from the pelvis to examine their organization, the student should observe the comparative larger size of the bladder and pelvis, the consequent straighter course of the last portion of the rectum, in the female than in the male; and the meatus urinarius, suspended by ligamentous attachments to the arch of the pubes.

Organization of the Internal Parts of Generation in the Female.

The *vagina* is composed of a thick membranous substance, which is lined by a mucous membrane, continuous with that of the vulva and uterus. Around the inferior extremity of the vagina, a plexus of veins, termed the *plexus retiformis*, is placed: it is an erectile spongy tissue, and has been named the corpus cavernosum vaginæ: it is of a grey color, and of a compact texture; thicker at the lower part, from whence it gradually becomes thinner, until it reaches the uterus. Some few fibres of the levator ani, are so connected with the sides of the vagina, as to have been designated, by some anatomists, the *constrictor vaginæ.*

The *mucous membrane* of the vagina is composed of numerous folds or rugæ, which take a regular transverse direction towards the lower extremity, but are less regular at the upper part of the vagina. These rugæ are crossed by two raphé, forming lateral columns, from which the rugæ appear to emanate. This mucous membrane is furnished with numerous follicles and lacunæ, particularly at its inferior extremity, where they are sometimes apparent to the naked eye.

The *arteries* of the vagina are derived from the internal pudic; and the *nerves*, from the sacro-lumbar plexus.

The *uterus*, or womb, is a hollow viscus, which contains the fœtus during the period of gestation. It is composed of a proper tissue of considerable thickness, which is now generally considered as muscular; a fibrous structure being traceable, both in a longitudinal and a transverse direction. It is externally covered by peritoneum, and internally is lined by an extremely delicate mucous membrane.

The *serous* or *peritoneal coat*, has already been described in the account of the broad ligaments.

In its organization, the *proper tissue* of the uterus is of considerable thickness, and of a dense and close texture; elastic, and of a greyish color. When impregnated, its

fibrous tissue becomes more apparent, particularly about the orifices of the fallopian tubes, where they form in a concentric arrangement, which Ruysch has described as an orbicular muscle.

The *cavity* of the *uterus* constitutes the hollow of the fundus and body, and may be considered as the true seat of gestation: from it, however, a canal is prolonged through the cervix to the os tincæ; being slightly dilated between these two points. This canal, in the impregnated uterus, is supposed to be closed until the period of parturition. The true cavity of the uterus is of a triangular figure, with curvilinear sides: in the two upper angles are placed the minute orifices of the fallopian tubes, while the lower angle terminates in the canal of the cervix.

The *mucous membrane* lining the uterus, is extremely delicate, and firmly connected with the proper tissue of the organ: so intimately, as to be with difficulty separated from it. Its color is whitish or grey, excepting towards, and during the period of menstruation, when it is tinged with red. It presents numerous minute villosities. The appearance of the mucous membrane lining the cavity of the body and fundus of the uterus, differs from that lining the neck: being, in the latter structure, less vascular, and having numerous oblique and transverse rugæ, and two longitudinal prominent lines, which pass on the fore and back part of the neck. Between these rugæ there are lacunæ, which are more apparent towards the os tincæ, where they sometimes assume the form of distinct vesicular bodies, described in some books as the ova of Naboth, their supposed discoverer.

The uterus is supplied with numerous *arteries*, which run in a remarkably tortuous course beneath the serous coat, before they enter the substance of the viscus: they are derived from the spermatic and internal iliac vessels.

The *veins* follow the same course with the arteries: are equally if not more tortuous. They have been named the sinuses of the uterus.

The *nerves* are derived from the sacro-lumbar plexus: the *absorbents* are numerous and large, and increase in size during gestation.

The *fallopian tubes* are composed of an erectile spongy tissue, somewhat resembling the corpus spongiosum of the urethra. They are externally covered by peritoneum, and are internally lined by mucous membrane.

Their serous or peritoneal coat, is derived from the broad ligaments.

Their erectile spongy tissue constitutes the principal bulk of the tubes, and has been supposed by some anatomists to be a continuation of the substance of the uterus itself. They each contain a canal, which, along the first half, is so small as scarcely to admit a bristle; but afterwards acquires the size of a goose-quill, becomes tortuous, and again contracts before it terminates in the fimbriated floating extremity. The corpus fimbriatum, which more or less resembles a half closed hand, has been called the *morsus diaboli:* it terminates in a fissure or opening, into which the impregnated ovum is received at the moment of separation from the ovarium, and is from thence conveyed along the fallopian tubes to the uterus.

The canal of the fallopian tube is lined by an extremely thin and delicate mucous membrane: it is soft, reddish, and presents several longitudinal folds or plicæ: it has a slightly villous surface, and is found to contain mucus, although mucous follicles have not not been discovered in it. It is at the fimbriated extremity of the fallopian tube that its mucous membrane opens into the serous cavity of the peritoneum, to grasp the impregnated ovum.

The *round ligaments* seem to be for the purpose of preventing retroversion of the uterus: they take much the same course as the spermatic cord in the male. They are composed of a fasciculus of fibres containing numerous vessels, of which they seem to be principally constructed. They are of a whitish color, narrower in the inguinal canal than in any other part of their course. Some anatomists believe that a

cremaster muscle gives a covering to these cords, but this is extremely doubtful: their use and structure, in fact, is but little understood. It sometimes happens, that portions of peritoneum extend along the round ligaments, into which portions of intestine may descend, and form a species of congenital hernia in the female.

The *ovaria* are enclosed in a thin cellulo-fibrous membrane, forming a proper capsule, having numerous prolongations extending from it into the parenchyma of the organ. They are placed between the layers of the broad ligaments; may be said therefore to be furnished with a serous coat. They differ in their appearance in different individuals: in some presenting a smooth, and in others an irregular surface. Their substance is composed of a soft spongy tissue, enclosing from fifteen to twenty small and transparent vesicles, about the size of millet-seed, first discovered by De Graaf, whence they have been named ovula Graafiana; around which the blood-vessels are more numerous and more minute than in the substance of the organ. They contain a fluid of a reddish color, and have smooth surfaces. It is one of these vesicles which, upon conception, bursting, yields its contents to the fallopian tube, along which it is conveyed to the uterus. A cicatrix is formed in the place of the vesicle, which has been supposed to mark the number of conceptions which may have occurred in any individual. These cicatrices have been termed the *corpora lutea*, are of a brownish yellow color; and by some physiologists it is supposed that these vesicles may burst from excessive excitement, without impregnation; and that such corpora lutea may be distinguished by their softer texture and color.

Their *arteries* are derived from the aorta, and correspond to the spermatic arteries in the male: the *veins* also take a similar course.

The Mammæ.

The mammæ are two rounded projecting glands, placed upon the anterior surface of the thorax, beneath the common

integuments; connected by loose cellular membrane with the great pectoral muscles.

They are formed for the purpose of secreting milk, a nutritious fluid, destined for the support of the infant child, until its organs of digestion are capable of receiving more solid food. Their developement and function have a remarkable consent with all the changes of the uterine system. They do not acquire their full growth before the age of puberty; in young females being scarcely more prominent than in the male.

When full grown they are round, prominent, and covered with a finer and softer skin than the surrounding parts.

Towards their centre, but somewhat inclining to the lower side, the nipple is placed; a conical projecting body of a dark red color, containing the excretory ducts of the mammæ. Around the nipple is an areola of extremely delicate thin skin, also of a dark color: in this is placed a circle of sebacious glands, which secrete an unctious fluid, to lubricate and protect the nipple from the saliva of the infant during the period of nursing.

The mammæ increase in size during the period of gestation; but towards the latter part of that period they acquire their greatest enlargement, and take on the secretion of milk, which continues many months, and appears to be kept up by the continued stimulus of the child; for when the child is withdrawn, and the milk extracted by artificial means, it soon ceases to be secreted, and the breasts decrease in size, though not to their former dimensions, being larger in women who have borne children, and remain much enlarged in those who have had many.

The areola also becomes darker in color during pregnancy and menstruation; and, with the nipple, remains darker in women after repeated conception: in young persons these parts are of a rosy tint. The nipple possesses an erectile tissue.

The child extracts the milk by means of suction, excluding the air by enclosing the nipple with its lips: it thus acts with

its tongue similar to a piston of an exhausting syringe. The nipple is elongated, and the lactiferous ducts drawn out from their previously coiled position.

Organization of the Mammæ.

The mammary glands are of a whitish firm consistence, and are composed of numerous minute lobes, collected into larger masses, from whence it receives an irregular surface; but which is not perceived externally, being imbedded in adeps and cellular membrane. From these minute lobules and aggregates, the lactiferous tubes arise; and as they collect towards the centre of the gland, increase in size. They are flexuous, very extensile, and semitransparent. The larger lobes, from fifteen to twenty in number, each sends a separate duct, which varies according to the size of the lobe from which it arises, and terminates in short conical sinuses; from the summits of which proceed canals, which do not communicate together, but occupy the centre of the nipple, opening on its surface.

Sir Astley Cooper has described a structure which he considers to be connected with the developement of the nipple, and which he has termed the *mammillary gland.* It is found in both the male and female infant, placed immediately beneath the nipple. It is by this structure that the white milky fluid, which frequently flows from the nipples of newly born children, is secreted. It is evidently a separate structure from that of the substance of the mamma; but if examined in the female, it appears to be made up of the coiled lactiferous tubes, as they are passing to terminate in the nipple.

The *arteries* of the mammæ are numerous, and are given off from the thoracic, axillary, intercostal, and internal mammary; having *veins* corresponding to the arteries, excepting some few which follow a subcutaneous course.

The *lymphatics* are numerous, and terminate in the axilary ganglia.

The *nerves* are from the brachial, plexus and intercostal.

The milk of the human subject differs from that of other animals, in having more saccharine matter, and less curd, and in not yielding butter. The curd increases in proportion to the time after delivery. The milk may be considered as one of the most compound of the animal secretions: it contains, besides hydrogen, carbon, oxygen and a small quantity of azote, muriate of soda, muriate of potash, phosphate of lime and other salts. The presence of muriate of potash in milk, and its not being found in the blood, has led to the supposition, that the constituents of the milk are furnished by the absorbent system: the salts of potash being found abundantly in the chyle formed from vegetable substances. We may observe, therefore, that the milk contains all the essential elements of nutrition for the infant; when it is itself incapable of the powers of assimilation, in proportion to the great rapidity of its growth.

Practical Remarks.

The female organs of generation are not liable to so complicated a series of diseases as the male, in consequence of the urinary apparatus being more distinct; they are, however, from the earliest periods, subject to various malformations, and diseases requiring surgical aid for their relief.

The *vagina* is liable to congenital malformations, the most frequent of which is an imperforate state, either produced by the mucous membrane forming a *cul de sac* over the orifice of the vagina, so as completely to close the opening; or in other instances by a thickening or accretion of the sides of the vagina, so that the whole passage is wanting.

These malformations frequently escape the notice of parents, and the surgeon is not consulted until that period of life when they occasion a mechanical obstruction to the menstrual discharge, and produce a train of symptoms very similar to those of pregnancy: such as, in addition to the absence of the menstrual discharge, flatulency, attended with eructation, morbid appetite, nausea, and occasional vomiting on the change of position from the recumbent to the erect posture, enlargement of the mammæ, and swelling of the abdomen, and various other uterine sympathies. The nature of these cases are difficult to determine, without an examination, when the malformation of the parts immediate elucidates their origin, and points out the means of relief.

If the imperforation depends merely on the mucous membrane it will be denoted by the protuberance of the membrane, forming a convex

fluctuating tumor; this is readily relieved by a free incision, from which the collected discharges will be evacuated; this must be followed up by constitutional remedies, which generally completes a cure.

When the imperforation is produced by a closure of the canal and consolidation of the vagina, the means of relief are attended with greater difficulty, and with consequences of a dangerous character; this arises from the depth and thickness of the parts to be cut through, and their proximity to important organs, which are, in consequence, liable to be wounded. Here a correct knowledge of the contents of the female pelvis, and the relative position of the parts contained, can alone enable the operator to direct his knife in the proper course, from the vulva to the os tincæ, for the purpose of evacuating the collected fluid.

My friend, Mr. Herbert Mayo, met with a case of this kind, in which the whole length of the canal of the vagina was obliterated, and which he relieved by passing a trocar in the direction of the uterus, and then directed a gorget into this opening in order to establish the canal. This patient completely recovered, and afterwards had a family.

From lacerations or ulcers, a similar effect is produced to that of malformations, from cicatrices, which, in the process of reparation, entirely close, or partially contract the canal, so as to render either dilatation by the use of sponge tents, or incision necessary, for the reestablishment of the natural size of the canal.

The *clitoris* is sometimes so large, from an inordinate developement, without any specific diseased action, as to require partial excision for the removal of this inconvenience. It is also subject to malignant disease, particularly of cancerous affections and ulcerations, which render its removal necessary. For the performance of this it is proper to place the patient in the same position as for the operation of lithotomy. A ligature will be required to secure the artery of the clitoris, which is in proportion larger than that of the penis.

The *nymphæ*, like the clitoris, are sometimes inordinately large, and this may occur to either one or both, so as to produce a projection beyond the external labia. The inconvenience arising from these enlargements require a similar treatment to that of the clitoris.

The *uterus*, more particularly the neck, is liable to malignant diseases, and these most frequently occur either to unmarried, or to women who have never borne children. The principal reason for the more frequent occurrence of these diseases in such persons is probably owing to the important functions of the uterus never having been called into action. Of late years, where the disease has only been in the neck, the parts have been extirpated with complete success; this has led surgeons to perform the more formidable operation of extirpating the whole

organ; but from the unfavorable results which have followed,—only two out of twelve having recovered, and they only surviving, one twelve, and the other eleven months,—and from the severe constitutional shock experienced by the loss of this organ, so violent as generally to destroy life in a few hours after the operation, it is more than probable that in future it will be entirely abandoned.

The mode of removing the neck of the uterus is simple: the patient being placed in the position for the operation for the stone, a speculum vaginæ is introduced to widen the vagina, so that the neck of the uterus may be seized with a double hook, and drawn forwards into the vagina, so as to admit of the excision of its neck; but little bleeding usually follows. I have, myself, seen Dr. Blundell remove the whole organ, in which operation he evinced so much dexterity and anatomical knowledge, that I cannot pass over his mode of operating without noticing it.

The patient was placed on a bed of a convenient height, in the position adopted in ordinary delivery; the operator, kneeling by the side of the bed, introduced the middle and fore finger of his left hand, with the blade of a curved scalpel secured between them, at the same time exploring with the fore finger, he ascertained the point at which the peritoneum is reflected from the vagina to the rectum, where he made an opening by insinuating the knife through the posterior wall of the vagina, into the *cul de sac* of peritoneum. This opening into the peritoneal bag was only sufficiently large at first to admit the point of the fore finger, when the knife was laid aside, as the intestines were immediately felt pressing against the admitted finger. The opening in the peritoneum was then enlarged by dilating it sufficiently with the fore finger so as to admit the middle, when the whole hand was passed into the vagina, (which in this case the organ readily admitted) and enabled the operator to place the tips of the fore and middle finger upon the fundus of the uterus, which he then retroverted, so as to bring it into the palm of his hand; then gradually withdrawing it into the vagina, through the opening he had made in the posterior wall, he there held it while he divided close to the uterus, the fallopian tubes, broad and round ligaments, which still held it in connection with the abdominal cavity; then drawing the uterus as far forwards as possible into the vagina, he separated it from that organ by careful incisions, so as to avoid the bladder and ureters.

The patient lost a very small quantity of blood during this operation, and bore it without evincing a great degree of pain: her nervous system, however, appeared to have suffered a greater shock than usually occurs where so little pain is expressed. This patient survived the operation twelve months, when she died from constipation.

The *ovaria* are liable to malignant diseases, both from schirrous

tumors and fungus hematodes. For the removal of these complaints the operation for extracting the ovary has been resorted to; but the difficulty of forming a just diagnosis of the disease, the danger attending the opening of a large serous cavity, and the impossibility of prejudging the extent of the morbid adhesions the organ may have formed, together render the propriety of such an operation doubtful, excepting only under the accumulation of some fortuitous circumstances, which may warrant the surgeon in its performance.

This operation can scarcely be described, and must vary with the size and direction of the developement of the tumor. The abdomen should be opened in all cases that will admit of it, in the line of the linea alba, in order to avoid wounding the branches of the epigastric artery; the extent of the opening must be regulated by the size of the tumor.

In consequence of the exposure of so large a cavity the temperature of the room in which the operation is performed is always a matter of considerable importance; and as the intestines generally protrude during the operation, cloths, wrung out in warm water, should be had in readiness to enclose them as long as may be necessary.

The ovaria are also liable to large dropsical accumulations, in which the fluid is contained sometimes in one cavity, at others in separate cells. At the commencement of this disease it may readily be distinguished from dropsy of the peritoneal cavity by the situation of the tumor being on one side of the mesian line; but as the accumulation of fluid increases the abdomen becomes generally distended. At this period, however, the diagnosis is usually sufficiently obvious, from the patient's constitution being in ovarian dropsy but little impaired, and suffering merely from the inconvenience of the weight of the tumor: while in peritoneal dropsy the health is usually much impaired, and generally connected with organic disease of the liver, or some other important organ. When ovarian dropsy has accumulated to an extent beyond which it cannot be borne, then, and not until then, should the surgeon recommend the evacuation of the fluid by operation; after having employed every medicinal means likely to prevent its accumulation, or to induce its absorption: such as diuretics, mercury, and tartarized antimony, to which may be added friction and pressure.

These accumulations are evacuated by the operation of paracentesis abdominis; and generally, as in common dropsy, the trocar is to be introduced in the linea alba, midway between the umbilicus and pubes; but sometimes the tumor is placed so much on one side as to require a lateral opening. The usual position in this operation is the sitting posture, but I should always recommend the recumbent, as the patient is then saved from the distressing symptoms which arise from the change in the position of the abdominal viscera, as the water becomes

evacuated. I have had constructed, to facilitate the evacuation of the water in this position, an elastic gum tube, three feet in length, armed with a stop cock at one end, while the other is made with a brass mouth, nicely to fit the canula. This tube can readily be directed over the side of the bed to a convenient vessel to receive the fluid.

In ovarian dropsy the trocar and canula should always be used, and not the canula recommended to be introduced through an opening made by a lancet, as the fluid is frequently of so viscid a consistence that it will not flow through the small apertures of such a canula.

This operation is to be considered as merely palliative, for the disease almost invariably returns, notwithstanding all the means which have been adopted in the various attempts made to effect a cure.

My friend, Mr. F. Toulmin, of Hackney, attended a woman, aged thirty-four years, who had an ovarian dropsy, and was, at the same time, in an advanced state of pregnancy. Fifty-two pints of water were drawn off, and in thirteen hours after she was delivered of a fine female child, which lived, did well, and was suckled by its mother. In two months afterwards the same quantity of fluid was again drawn off: after which every two months the operation was repeated until her decease, which was in eighteen months from her delivery.

The *mammæ*, both from their structure and function, are particularly liable to a class of diseases peculiar to the female: in the male, however, the nipples are subject to some of the diseases incident to the female.

The diseases of the breast may be divided into three classes:—those which are caused by external injuries, those which are connected with the function of the gland, and those which arise from specific constitutional diseased action.

Of the first class:—Common inflammation, arising from external violence, is indicated by pain, redness and swelling, similar to inflammation in other parts, and requires the same constitutional and local means of treatment: but the breast, like other glandular structures, is slow in the progress of its diseased changes, and equally tardy in the process of restoration.

Inflammation, therefore, frequently runs into a chronic form, inducing a general enlargement and induration of the gland, which may be relieved by the occasional application of a few leeches and emollients. Even in this simple form of disease the constitution so frequently sympathises, that tonics may be required; and if the uterine actions are irregular, steel may be beneficially administered.

When inflammation, induced from a blow, or other external violence, terminates in the formation of an abscess, it is more frequently in the chronic than in the acute form, accompanied by symptoms so insidious

that the presence of an abscess has frequently escaped the surgeon's notice. In this state there is considerable difficulty in forming a just diagnosis, particularly when the history of the disease has not been well ascertained, for the tumor presents a very indistinct fluctuation, a general surrounding hardness, and puts on many of the appearances which are of a malignant character. I have known a patient recommended by a skilful surgeon to submit to the operation for the removal of the breast, when another, who had paid particular attention to this class of diseases, by the puncture of a lancet at once discovered its true nature, and saved the patient from this painful operation; hence the necessity, in all doubtful cases, of puncturing the tumor, to ascertain the possible presence of matter, before proceeding to extirpate the breast.

Inflammation of the breast is frequently excited in young females of a full plethoric habit, immediately after the age of puberty, and may occur as late as the age of thirty years. This inflammation will sometimes induce an irritable state either of the whole gland, of one or two of its lobes, or the formation of a small tumor, which is very prominent, as if superadded to the substance of the breast. In either of these cases the slightest pressure causes considerable pain, extending into the axilla, and in the course of the inner cutaneous nerve; these tumors are usually attributed to the state of the constitution, but, in fact, are connected more with changes in the uterine system than with a particular constitutional diathesis. Leucorrhœa is often a cause of this complaint, which cannot be removed until the leucorrhœa is suppressed, when they will frequently simultaneously subside.

For the treatment of the irritable breast great care must be taken not to diminish the strength of the patient, as you cannot diminish constitutional power without increasing nervous irritability. Plasters of equal parts of soap and belladonna, conium poultices, evaporating lotions, either separately or mixed with poultices, may be variously recommended, as local applications; if from these remedies relief is not obtained, leeches are occasionally necessary. As constitutional means, calomel and opium should be prescribed, to diminish irritability; and ammonia, rhubarb, with bitter infusions, to improve the general system. This treatment must be varied according to the state of the uterus, or the existence of leucorrhœa.

The next disease connected with the function of these organs is that which is commonly named milk abscess; this arises either from the suppression of the secretion, from cold, from the great distention of the organ when its secretion is superabundant, from the obliteration of one or more of the lactiferous tubes, or from malformation of the nipple. The worst form is when induced from the first of these causes, which

leads to a great degree of irritative fever, and requires the most active constitutional and local remedies. When it arises from the second cause, relief is almost invariably obtained by the milk being withdrawn either by the mouth or other mechanical means, and by regulating as much as possible the secretion of the gland. From the third cause, the tumors which form present fluctuating prominences, opposite to the obliterated tubes, and generally near to the nipple. When such tumors occasion great irritation, they must be opened with a lancet, otherwise these accumulations go on to produce troublesome abscesses. These tumors generally contain pure milk.

The malformation of the nipple, may either be such as admits of a remedy or not. When in a flattened state, the nipple may by degrees be elongated by mechanical means, so as to render it capable of performing its natural function; but when imperforate, or, as sometimes happens, when entirely wanting, there seems to be no remedy, unless, in the first instance, perforation with a needle be attempted: as the obliteration may arise from the mucous membrane of the canal only, and not from an accretion of the whole of the ducts themselves.

From the existence of the hydatid disease of the breast occurring only from about the age of twenty-five to the cessation of menstruation, I feel inclined to class it with the functional diseases of the organ; although, during this period, it may be occasionally induced from the inflammation following local injuries. From the third class we appear to have every reason to separate it, as its removal by excision effects a radical cure, and proves that it does not depend upon a constitutional diathesis. The diagnosis of this complaint is sometimes difficult, as it occasionally puts on the appearances of the fungoid disease; but the unimpaired state of the patient's health, and the general history of the progress of the disease, in most instances points out its true nature.

Cancer and fungus hæmatodes constitute the third class of disease incident to the mammæ, and depend upon a peculiar malignant diathesis.

When these diseases are once established, little hope of a cure can be entertained either from the use of medicines or from their excision, as we know of no remedy which can alter the constitutional exciting cause, and which remains when the tumors themselves are removed.

Fungus hæmatodes, not inappropriately termed soft cancer by the older writers, usually occurs from the age of twenty-five to the age of thirty-five, but occasionally as early as sixteen; whereas, cancer is a disease of a much later period, rarely putting on a serious form until after menstruation has ceased. May not the rapidity of the growth of the former, when compared to the latter disease, depend more upon the period of life at which it occurs, than on any specific difference of

action? I shall not enter into a minute detail of the appearances assumed in these diseases, as there are so many works extant upon the subject, that it is wholly unnecessary here.

The removal of tumors from the breast consists of a simple piece of dissection. Care should be taken to leave sufficient integument to close the wound, and on the other hand, not too much, so as to lead to the formation of abscesses. During the operation if large blood vessels are divided, they should be immediately secured, unless they are so situated as to be conveniently commanded by an assistant; smaller vessels need not be secured until after the removal of the tumor. In these extirpations great care should be taken that no diseased portions are allowed to remain, in order to prevent as much as possible the return of the complaint, which, however, with every possible care, too frequently occurs, from the tendency of such constitutions to regenerate the disease. The after treatment consists in the administration of alterative medicines, recommending, at the same time, change of air and scene, in order to divert the action of the mind as well as to change that of the constitution.

In conclusion of this subject it may be remarked, that at the advanced periods of life this disease is so slow in its progress, that the patient is more likely to survive for a greater period the effects of the disease, than when subjected to the operation.

LECTURE XXV.

OF THE THORAX AND ITS CONTENTS.

The cavity of the thorax, placed between the cervical region and the abdomen, contains the organs of respiration with their investing membranes the pleuræ; the heart, the principal organ of the circulation of the blood, with its investing membrane the pericardium; and the mediastina, with their contents.

The structure of this cavity has already been described, with regard to its bony parietes (*Vide Vol. I. p.* 88.), and with respect to its muscular parietes. (*Vide Vol. II. p.* 166.) It is here therefore only necessary briefly to recapitulate, that this cavity is formed principally of a bony structure, which gives it great strength, and of elastic cartilage, which, with the vital energy of numerous muscles, contribute to effect its alternate enlargement and contraction, and consequently the simultaneous action of the lungs during respiration.

We have hitherto merely considered the cavity of the chest in reference to its bony and muscular parietes; we must now, however, enter into such considerations as will point out, how perfectly this cavity is constructed for the various purposes for which it is employed. Thus, in the process of deglutition, the food, in its passage from the pharynx to the stomach, passes through the cavity of the thorax; and when assimilated, is returned in the form of chyle through it, to enter the venous system at the lower region of the neck. The air we breathe also has its ingress and egress in respiration; while the blood we circulate emanates from the heart in this cavity, to supply the whole of

the body, from whence it is returned to it by the venous system. Numerons important nerves also traverse this cavity, in their course to various ultimate distributions. Hence it will be readily seen, that a correct knowledge of the various openings into the cavity of the chest is a point of considerable anatomical importance.

At the apex of the cone, or upper part of the chest, we find an opening which is bounded behind, by the first dorsal vertebra; before, by the upper piece of the sternum; and laterally, by the first ribs. This opening has a slanting direction from behind and above, to before and below. The parts passing into this opening are the œsophagus and trachea, the pneumogastric, sympathetic and phrenic nerves, the venæ innominatæ, and internal mammary arteries: while the parts passing out are the arteria innominata, the left carotid and left subclavian arteries, the thoracic ducts, the first dorsal and the recurrent laryngeal nerves, portions of the pleuræ, and the longi colli muscles. These important parts are protected from compression by the mode of articulation of the two first ribs, which admit of the elevation of the sternum, and consequent enlargement of the opening, but does not allow of any diminution.

The base of the cone, or lower part of the chest, is entirely formed of the diaphragm, which is placed in a slanting direction, precisely the reverse of that of the upper opening, namely: from before and above, to behind and below. Hence the perpendicular axis of the chest is much greater posteriorly than anteriorly.

The diaphragm, which forms the partition between the chest and the abdomen, is perforated by three principal openings for the passage of several important parts. On the right side of the centre of the tendon of the diaphragm there is a triangular opening, for the passage of the vena cava ascendens, accompanied by a few twigs of the phrenic nerve. Between the crura of the diaphragm, and in the mesian line of the body, an opening is left; bounded posteriorly by the lumbar vertebræ, which transmits the aorta,

vena azygos, and thoracic duct. Above, and rather to the left side of this opening, a third space is formed by the decussation of the two crura of the lesser muscle of the diaphragm, through which the œsophagus passes, and the par vagum; while the sympathetic and splanchnic nerves pass through the substance of the lesser muscle itself, in their passage to the abdomen. Of these three openings, that which transmits the œsophagus is the only one so constructed as to admit of the compression of the organs passing through it, and which compression assists in the propulsion of the food from the œsophagus into the stomach.

We may now proceed to the examination of the interior of the thorax, and to describe the splanchnic membranes which cover the organs it contains; after which, we shall continue with the thoracic viscera individually.

In order to open the thorax, so as to demonstrate the pleuræ, the intercostal muscles should be carefully removed; and then sawing through the six superior ribs just anterior to their angles, and dividing their cartilaginous extremities, they should be raised, taking care not to wound the pleuræ. The thin semitransparent membrane which now presents itself to view, is the pleura costalis; which name it bears, where it forms a lining to the ribs and intercostal muscles. There are two distinct pleuræ in the cavity of the chest, each forming a separate closed serous bag, occupying the lateral portions of the thorax. In the centre, between the two bags, spaces are left, which are named the mediastina. The lungs are surrounded by the pleuræ, precisely in the same manner as the abdominal viscera are by the peritoneum: and it is at this period of the dissection that the student should trace the reflections of these membranes.

The subject being in the horizontal posture, and the ribs having been removed as before described, the student should tear or cut through the pleura costalis, by which means he exposes the lung on that side of the chest, as if free within the cavity; but, by examination, he will discover that it is surrounded by pleura, precisely in the same manner as, on

opening the cavity of the abdomen, the small intestines are found to be surrounded by the mesentery.

The reflection of the pleura may be traced commencing from the side of the sternum, from which the layer on the one side converging towards that on the other, leaves a small space between the two, termed the anterior mediastinum. Each layer passes backwards upon the pericardium, to the anterior surface of the pulmonary vessels, proceeds along them to their entrance into the lung; at which point the membrane is reflected from the vessels upon the anterior half of the concave surface of the lung, winds over the acute anterior edge of the lung, covers the external convex surface; extending upwards to the apex, and downwards to the base of the organ; winds around its posterior obtuse edge, covers its posterior concave surface, and gaining the point where the vessels enter, passes from the lung to their posterior surface; running then to the under surface of the pericardium, upon which it has a tendency to approach the pleura of the opposite side: from thence it is directed to the side of the spine, forming one side of a triangular space, which is termed the posterior mediastinum: from the side of the spine it passes to the heads of the ribs, covering the ganglia produced by the union of the sympathetic and intercostal nerves; it then proceeds along the inner surfaces of the ribs and intercostal muscles, and passes to the side of the sternum—from whence we commenced our description.

The sternum should now be lifted up, after dividing the cartilages of the ribs close to their bony parts, on either side, and the connection of the diaphragm to the ensiform cartilage. The pleura will then be observed to form a complete partition between the right and left lung: the lung on the left side is, however, smaller, than that on the right, in consequence of the space in the mediastinum occupied by the heart, and its investing pericardium, being situated more on the left than on the right side.

The *anterior mediastinum* is a triangular space between the pleura, in front of the pericardium and behind the ster-

num: opposite the fourth rib it alters its perpendicular direction, and is inclined to the left, terminating opposite the sixth rib. Above and below the heart, the anterior mediastinum extends the whole depth of the chest from the sternum to the spine; but in the middle part only, from the sternum to the pericardium.

The contents of the anterior mediastinum are, the thymus gland, small absorbent glands, and absorbent vessels, invested in loose cellular membrane.

The *thymus gland*—the use of which is entirely unknown—appears to be wholly connected with the economy of the fœtal state. It is a soft, lobular, glandular body, of a yellowish or whitish color, which, at that early period, occupies a space extending from the thyroid gland, nearly as far as the diaphragm, within the anterior mediastinum. From the fœtal period it gradually diminishes in size, until, in the adult, it is nearly absorbed; and in old persons, can scarcely be distinguished from the cellular membrane in the mediastinum. Its figure is oblong, its upper and lower extremities being unequally divided into two portions by a fissure, which leaves the portions on the right side thicker and longer than those on the left. A sulcus extends from the upper to the lower fissure, along the anterior surface of the gland.

It is covered by a thin capsule, which sends prolongations into its substance, dividing it into several lobules of unequal size. These lobules are filled with vesicles, which appear to possess a general communication, in which a milky viscid fluid is detected. An excretory duct has not been discovered; its blood-vessels and lymphatics are, however, very numerous. The arteries arise from the internal mammary, inferior thyroid, bronchial, mediastinal and pericardiac, and are accompanied by corresponding veins. Its nerves are derived from the pneumogastric, inferior cervical ganglia and diaphragmatic nerves.

Practical Remarks.

The size of the thymus gland in young children, renders the operation of tracheotomy infinitely more difficult and dangerous than at a later

period: ascending as it does from the thorax, sometimes even as high as the thyroid gland, it so covers the whole length of the anterior surface, that the surgeon has no space left to make an opening in the trachea, without wounding this gland; still, however, those urgent circumstances which usually render this operation necessary, leaves the surgeon no choice as to the necessity of its performance, with a care, however, which must be in proportion to the increase of difficulty.

The centre of the mediastinum is occupied by the heart, and its investing membrane the pericardium.

The pupil has here to observe the attachments of the pleura to the pericardium, and the direction of the long axis of the heart; the phrenic nerves, taking their course between the two pleuræ and pericardium, on either side, towards the diaphragm: the course of the large arteries arising from the heart, and of the veins passing to it; and particularly the course of the left vena innominata, crossing in front of the arch of the aorta, to terminate in the descending cava. The minuter particulars of the position and relative situation, and whole anatomy of the heart and arteries, will be given when treating of the circulating system.

The *posterior mediastinum* is to be exposed by raising the right lung, and drawing it over as much as possible to the left side of the chest; and by cutting through that portion of the pleura which is reflected from the posterior surface of the right pulmonary vessels, and concave surface of the right lung to the spine. The space thus exposed is of an irregular triangular figure, its base being formed by the spine, its apex, in the centre by the pericardium; but above and below it is continuous with the anterior mediastinum, and laterally with the two pleuræ.

Its extent is from the upper part of the third to the seventh dorsal vertebra. It contains lying on the spine through its whole course the aorta to the left, the vena azygos to the right, and the thoracic duct between the two, while the œsophagus and par vagum pass in their front. Immediately at the commencement, or upper part of the posterior mediastinum, the division of the bronchi may be seen.

The pupil should here observe, that the œsophagus does not take a straight eourse through the posterior mediastinum: at the upper part, it is placed to the right of the aorta; in the middle, immediately in front; and below, to its left side. The par vagum, in their course upon the œsophagus, are so placed that the right is on the posterior, and the left on the anterior surfaec of that organ.

We need not further mention the particulars of the other organs eontained in the posterior mediastinum, as they will be separately described with the systems to which they belong.

At this period of the dissection, both the pulmonary and arterial systems equally present themselves to our notice; and are each so important and so intimately connected, that a difficulty arises, both in an anatomical and physiological point of view, which to consider first: I shall, however, pursue the usual eourse of my lectures, and eommence with the organs of respiration.

Anatomy of the Organs of Respiration.

The best opportunity of observing the relative position of the blood-vessels of the lungs now offers itself; for which purpose the pleuræ should be separated eompletely from the pulmonary vessels, and the pericardium removed from the heart. From the anterior surfaee and right side of the heart the pulmonary artery arises, taking its course as a single trunk upwards, slightly backwards and to the left, as high as the concavity formed by the arch of the aorta; at which point may be observed an impervious cord conneeting these two vessels, which is the remains of the fœtal ductus arteriosus. Here the pulmonary artery divides into a right and a left trunk: the right takes its course behind the ascending aorta, behind the descending or superior cava, in front of the right bronchus, which it somewhat embraces, and enters the right lung, dividing into three principal branches.

The *left* pulmonary artery, whieh is shorter but larger than the right, passes below the arch, in front of the de-

scending aorta and its corresponding bronchus, to terminate in the left lung, dividing only into two principal branches. These vessels afterwards ramify in the lungs, in a manner which will be explained with their intimate parenchyma.

The *pulmonary veins* arise from the ultimate distribution of the pulmonary arteries, and pass from the lungs on either side, forming two large vessels: a superior and inferior right, and a superior and inferior left pulmonary vein.

The *superior right* pulmonary vein emerges from the right lung, below the right bronchus, and passes obliquely downwards, to terminate in the upper part of the right side of the left auricle of the heart.

The *inferior right* pulmonary vein emerges from the inferior lobe of the right lung, and is directed obliquely upwards, to enter the inferior part of the right side of the left auricle of the heart; the right pulmonary artery being placed between these two veins.

These veins are much concealed by the vena cava, and right auricle of the heart.

The *left pulmonary veins* take much the same course, are however more exposed to view, and less separated from each other; and enter on the left side of the left auricle of the heart, in a similar manner to those on the right side.

The heart should now be removed from the body, in order to expose more effectually the division and the course of the air-tubes to the lungs. In the consideration of the air-tube, we necessarily refer to its natural divisions into larynx, trachea, and bronchi; and as the organization and function of the lungs equally depend upon the structure of these parts, it is sufficiently evident that they should be described before the lungs themselves; although we must leave the thorax for a time, for that purpose.

Anatomy of the Larynx.

The *larynx* forms the upper and larger part of the windpipe; it is situated on the anterior part of the middle of the neck, reaching from about the upper part of the fourth to

the lower part of the fifth cervical vertebra. It is bounded above, by the os hyoides; below, by the trachea; in front, by the thyroid gland; laterally, by the carotid sheaths; and behind, it is separated from the spinal column by the pharynx.

The larynx is principally composed of five cartilages: the upper is the *thyroid* or *scutiform*, which is of a quadrilateral figure, placed on the anterior part of the neck, forming a prominence particularly observable in the male adult.

Immediately below the thyroid is placed the *cricoid* cartilage, which differs from the thyroid, being completely annular in its form. It occupies the lowest part of the larynx, and is attached to the first ring of the trachea. These two cartilages principally maintain the form of the larynx, and its constant open state for the transmission of the air; serving also in some measure for the alterations of the voice, in a manner that will afterwards be described when speaking of the particular motions of the larynx.

Above and at the posterior part of the cricoid, two other small cartilages are articulated, which are termed the *arytenoid*. They rise up above the level of the cricoid, so as to form a concavity, which may be said to resemble a portion of the circumference of a basin, in conjunction with the fore part of the thyroid cartilage; and are endowed with a motion upon the cricoid, which tends to open the glottis or aperture of the larynx. But it is not only these cartilages which tend to alter vocal sounds, there being other structures to produce such changes.

The *epiglottis* is the fifth cartilage of the larynx; so, at least, it is usually termed; but in fact it is fibro-cartilaginous, having a considerable quantity of fibrous tissue entering into its composition, from which it derives its peculiar physical property—elasticity. It is connected by a middle ligament, to the base of the tongue; by two lateral ligaments, to the cornua of the os hyoides; and posteriorly, by two others, to the arytenoid cartilages. Its form is irregularly conical, and is made to overlap the glottis in the act of swallowing, by the tongue thrusting it backwards, and the

larynx being raised at the same time, by the action of some of the muscles of deglutition.

These five cartilages are connected with each other by ligaments, and are destined to be moved either by muscles common to the cartilages, as a whole organ, or upon each other by muscles proper to individual parts.

The larynx is supplied with arteries, veins and nerves, and its interior is lined by mucous membrane.

The *thyroid cartilage* is the upper and largest of the five cartilages of the larynx: it resembles in form the breast-plate of a cuirass, having a prominent vertical line down its centre, which is produced by the junction of two plates extending obliquely backwards, to form the sides of the cartilage, leaving a large open space posteriorly.

This cartilage presents an external and an internal surface; an upper, an inferior, and two posterior edges; and posteriorly, two superior and two inferior angles, which are prolonged, and are termed the superior and inferior cornua.

The *external* or *anterior surface* presents, in the middle line, a perpendicular prominence, which projects more or less in proportion to the acuteness of the angle formed by the union of the two lateral plates, and is always more marked above than below, and is termed the pomum Adami. The sides are slightly concave, and are marked by a line which passes from the upper part of the posterior edge obliquely downwards and forwards towards the middle of the lower edge, this gives attachment to the sterno hyoidei and sterno thyroidei muscles. Posterior to this line, the cartilage is marked by the attachment of the constrictor pharyngis inferior; and is sometimes perforated by a foramen, for the passage of blood-vessels.

The *internal* or *posterior surface* forms an angular cavity, corresponding to the anterior surface. In the middle sulcus, formed by the union of the two plates, there is a slight roughness below, for the attachments of the vocal cords. On either side, from the middle of the lower parts of these

plates, the thyro arytenoidei muscles arise; and posterior to these, the crico, arytenoidei laterales are attached.

The *upper edge* presents a curvilinear or cordiform appearance; having a deep notch in the centre, which is less marked in the female than in the male; and gives attachment, along its whole length, to the thyro hyoid ligament.

The *lower edge* gives attachment to the crico thyroid ligament, and is marked by two tubercles, in which the two oblique lateral ridges terminate. The lower edge also gives attachment to the crico thyroidei muscles.

The *two posterior edges* are perpendicular and obtuse; and where they are attached to the superior and inferior edges, they form angles, which are prolonged into processes termed the *cornua,* and of which the upper are larger than the lower.

The *two superior cornua* are connected by round ligaments to the os hyoides; the *two inferior*, by smooth concave surfaces on their inner side, to the cricoid cartilage; the two posterior obtuse edges give a partial insertion to the stylo and palato pharyngei muscles.

The *cricoid cartilage* is the thickest of the larynx; and instead of leaving an open space behind, like the thyroid, there presents its largest surface; while anteriorly it is small, and forms a complete annular structure. Its figure is extremely irregular; but in it may be distinguished an external and an internal surface, a superior and an inferior circumference.

The *external surface* is very narrow anteriorly, and gives attachment to the crico thyroidei muscles. As it passes backwards, its sides become broader, which are furnished superiorly with two polished articulating surfaces, for the attachment of the inferior cornua of the thyroid cartilage. From the sides it continues to enlarge, until its broadest surface is formed quite posteriorly, where it presents a quadrilateral figure, pointed above and straight below, divided by a mesian prominence, on each side of

which there are roughened concave surfaces, for the attachment of the crico arytenoidei postici muscles.

Its *inner surface* is smooth, and is lined by the mucous membrane of the larynx.

Its *superior circumference* may be divided into an anterior and a posterior part: the anterior, forming two thirds, is attached to the crico thyroid ligament; while the posterior rises higher up in the space left by the diverging plates of the thyroid, and presents a middle elevation, on each side of which is a smooth convex articular surface, inclined outwards, to receive the corresponding concave base of the arytenoid cartilage. A small roughness is usually described anterior to these articular faces, into which the crico arytenoidei laterales are said to be inserted; but the fact is, they are only inserted into the bases of the arytenoid cartilages; for it must be obvious, that their insertion into the cricoid, from which they arise, would prevent their action.

The *inferior circumference* is nearly horizontal in its whole extent, and is attached to the first ring of the trachea, by a broad intervening ligament.

The *arytenoid cartilages* are two in number, and are placed above the cricoid, at the upper and back part of the larynx. Their form is somewhat of an irregular triangle, their *bases* being fixed to the cricoid cartilage, and their *apices* directed upwards, forwards, and towards each other: they are somewhat twisted, and present an *external* convex and an *internal* concave edge, an *anterior* and a *posterior* surface.

The *bases* of these cartilages are made up of an articulating surface, which is concave, and opposed to the convex articular surface of the cricoid cartilage, in such a manner as to admit only of a lateral motion.

The *apices* are pointed and somewhat directed towards each other, and are occasionally furnished with a small isolated portion of cartilage, which has been termed by Soemmering, the cornula laryngis.

Their *anterior* surface is concave below, and convex

above, owing to their twisted form; and is covered by mucous membrane, and the arytenoid gland. They give attachment to the vocal cords, and to the thyro arytenoidei muscles.

Their *posterior* surfaces are concave, and have the arytenoideus transversus muscle attached to them.

Their *external edge* is convex, and furnished with a tubercle, into which are inserted the crico arytenoidei laterales and postici muscles. It is these cartilages which, by their motions on the cricoid, enlarge or diminish the opening of the glottis.

The *epiglottis* is placed above the opening of the glottis, at the base of the tongue, to which it is connected, as well as with the os hyoides superiorly and anteriorly; below, with the thyroid cartilage, at its anterior fissure; and posteriorly, by the aryteno-epiglottidean ligaments, to the arytenoid cartilages. Its form is oval, and not unlike to the shape of the tongue, excepting that it is narrower at its base than in its centre. Its color is of a pale yellow: it is composed of a very elastic tissue, by which, under common circumstances, it is raised from the glottis. Its superior or lingual surface is convex from side to side, and concave from behind to before. It is covered by the mucous membrane of the mouth, which connects it with the tongue; and posteriorly, by the epiglottidean gland. Its laryngeal or under surface, is concave from side to side, and convex from before to behind—just the reverse to the lingual surface; and is covered by the mucous membrane of the larynx, which connects it, as has been before described, with the arytenoid cartilages.

The two surfaces of the epiglottis are furnished with a number of mucous follicles, and are perforated by minute foramina, for the passage of filaments of nerves.

Ligaments of the Larynx.

The five cartilages of the larynx which we have just described, are connected with each other by seventeen ligaments, namely: three broad, two round, four capsular, four vocal, and four to the epiglottis.

The three broad ligaments connect their cartilages at their anterior part.

The superior or *thyro hyoideal ligament,* commences from the lower and posterior edge of the os hyoides, and passes downwards, to be inserted into the whole length of the upper edge of the thyroid cartilage. Its anterior surfaee is covered by the sterno hyoidei, omo hyoidei and thyro hyoidei muscles: its posterior surface by mucous membrane, by the epiglottidean gland, and by the base of the epiglottis itself.

The middle or *crico thyroideal ligament,* passes from the whole length of the under edge of the thyroid to the upper edge of the cricoid cartilage, being stronger in the centre than it is laterally. It is covered anteriorly by the sterno hyoidei, sterno thyroidei, and crieo thyroidei muscles; it is also perforated by a small branch of the superior thyroideal artery. Its posterior surface is covered by the mucous membrane of the larynx.

The third and lower broad or *crico-tracheal ligament,* proceeds from the lower edge of the cricoid cartilage, and proceeds to the upper edge of the first ring of the trachea. Its anterior surfaee is covered by the sterno hyoidei and sterno thyroidei muscles; and its posterior surface is lined by the mucous membrane common to the larynx and trachea.

The two *round ligaments,* are strong rounded cords, proceeding from the under surface of the extremities of the cornua of the os hyoides, to the upper surface of the superior cornua of the thyroid cartilage. In the substance of these ligaments there is generally found a small isolated rounded body, which is either cartilaginous or bony, depending upon the age of the subject.

The four *capsular ligaments,* are two which attach the thyroid to the crieoid, and two which form the crico arytenoidean articulations.

The arthrodial articulations, formed by the inferior cornua of the thyroid cartilage and articular faces on the sides of the crieoid, are strengthened by capsular ligaments, which

are sometimes described as anterior and posterior fasciculi; but the fibres so completely surround the joints, as more properly to be called capsular.

The crico arytenoidean arthrodial articulations, are formed precisely in a similar manner to the above, and attach the bases of the arytenoid to the upper and back part of the cricoid cartilage. These, like all other arthrodial articulations, are furnished with muscles, which will hereafter be described with the particular motions they are destined to perform.

The four *thyro arytenoid ligaments*, or chordæ vocales, proceed, two on either side, from a projection upon the fore part of the base of each arytenoid cartilage, and pass forwards, converging towards those on the opposite side, to be inserted into the angle formed on the inner side of the thyroid cartilage, by the junction of its two lateral plates. The triangular space between the two lower cords is termed the *rima glottidis;* while the space between the upper and lower cord on the same side is called the *sacculus laryngis*, which is formed by the mucous membrane, as it is reflected from the one cord to the other. Externally the vocal cords and sacculi laryngis are bounded by the thyro arytenoidei muscles.

The four ligaments of the epiglottis, as they are termed, are little more than the reflections of mucous membrane which give attachment to this organ, above, to the os hyoides and tongue, in the centre forming what has been termed the frænum epiglottidis; below, to the thyroid cartilage; and behind, to the two arytenoid cartilages. The folds which pass to the arytenoid cartilages form, in fact, a part of the glottis.

Of the Muscles of the Larynx.

We have already described in the second volume, several muscles which act generally in raising or depressing the whole of this organ; but we have yet to describe those muscles which are proper to the larynx, and act upon the

vocal cords. These may be divided into those which open the larynx and enlarge the rima glottidis, those which close the larynx and contract the rima glottidis, and those which regulate the tension of the vocal cords.

Two pair of muscles are destined to open the larynx, or separate the vocal cords from each other, namely: the crico arytenoidei postici, and the crico arytenoidei laterales.

The *m. crico arytenoidei postici*, are situated at the back part of the cricoid cartilage, and *arise* on either side of its posterior mesian line: the fibres pass upwards and outwards, to be *inserted* into the convex edge of the base of each of the arytenoid cartilages, at a point between the insertions of the arytenoideus muscle, which is behind, and of the arytenoidei laterales, which is anterior to it. The posterior surface of these muscles is covered by the mucous membrane of the pharynx: anteriorly they are in contact with the cricoid cartilage.

Use.—To draw the arytenoid cartilages outwards, and consequently to enlarge the rima glottidis.

The *m. crico arytenoidei laterales*, are situated at the sides of the cricoid cartilage, and *arise* from a space between, and anterior to the crico thyroid and crico arytenoidean articulations: the fibres pass obliquely upwards, backwards and inwards, to be *inserted* into the fore part of the convex edge of the base of the arytenoid cartilages, where its fibres become mingled with those of the last described muscles. Its outer surface is directed towards the thyroid cartilage, from which it is separated by cellular membrane: its inner surface is lined by the mucous membrane of the larynx.

Use.—To draw the arytenoid cartilages forwards and outwards, and consequently to enlarge the rima glottidis.

The combined action of these four muscles cancel each other as to their anterior and posterior direction, and admit only of the enlargement of the rima glottidis; but when the postici act alone, they render the vocal cords tense, at the same time that they enlarge the opening; while on the contrary,

when the antici act alone, they relax the vocal cords at the same time they open the rima glottidis: so that the first pair of muscles contribute more particularly to the production of acute tones, while the second act in the production of grave tones.

The antagonists to these four muscles, and which close the rima glottidis, are three in number: the arytenoidei obliqui, and the arytenoideus transversus.

The *m. arytenoidei obliqui—arise* on either side from the inner concave edge of the bases of the arytenoid cartilages, and pass obliquely upwards and inwards, to be *inserted* into the apex of the opposite cartilage, from which they arise, crossing each other in their course. The posterior surface of these muscles is covered with the mucous membrane of the pharynx, and their anterior surface is in contact with the arytenoideus transversus muscle.

Use.—To draw the arytenoid cartilages towards each other, and consequently tend to close the glottis.

The *m. arytenoideus transversus*, is placed between the two arytenoid cartilages, and is covered by the two last described muscles; and is so closely connected with them, that the three have been frequently described as one muscle. It *arises* from the concave edge of the base of one arytenoid cartilage, and passes across to be *inserted* into the corresponding part of the opposite.

Use.—Similar to the two last, excepting that it closes the rima glottidis directly; while the two obliqui may act singly or together, and modify the inflections of the voice.

The pair of muscles which directly regulate the degree of tension of the vocal cords, are the crico thyroidei; while the thyro arytenoidei influence the intensity of sound, withdrawing the mucous membranes, so as to leave the vocal cords in the best possible state for their vibration.

The *m. crico thyroidei—arise* on either side of the fore part of the cricoid, ascend obliquely upwards and outwards, to be *inserted* into the lower edge of the sides of the thy-

roid cartilage. The anterior surface of these muscles is covered by the sterno thyroïdeus: posteriorly they are in contact with the crico thyroideal broad ligament.

Use.—To raise the cricoid towards the thyroid cartilage, and thus to direct the posterior part of the cricoid with the two arytenoid cartilages backwards, and consequently to stretch the vocal cords.

The *m. thyro arytenoidei—arise* from the middle and lower part of the inner surface of the lateral plates of the thyroid cartilage: they proceed backwards and slightly inwards, to be *inserted* into the anterior surface of the base of the arytenoid cărtilage, immediately above the insertion of the crico arytenoidei laterales. Their outer surface is in contact with the thyroid cartilage: their inner surface is not only opposed, but is attached to the mucous membrane of the larynx, where it forms the sacculi laryngis, to which these muscles form an outer boundary.

Use.—When these muscles act alone, they must necessarily tend to open the glottis, and relax the vocal cords; but when they act in conjunction with the preceding pair, they are prevented from drawing the arytenoïd cartilage forwards, and act only upon the mucous membrane of the sacculi laryngis, which they draw from the vocal cords, so as to prevent it from acting as a damper to their vibrations.

The *arteries* of the larynx are derived from the superior thyroideal branch of the external carotid, and from the inferior thyroideal branch of the subclavian artery.

The *veins* correspond with the course of the arteries.

The *nerves* are derived from the pneumogastric by two branches, a superior, and inferior or recurrent laryngeal, and from the two superior cervical ganglia of the sympathetic.

Its *absorbents* terminate in the deep jugular glands, situated in the course of the carotid sheaths.

The Thyroid Gland.

The thyroid gland is placed at the lower and anterior part of the larynx, and covers the first rings of the trachea. It is a glandular structure, of a reddish color, larger in the child and female than in the male adult, and its use is entirely unknown. Its color varies from a brownish red to a

grey or yellow : its form is irregular, being composed of two oval lobes, thieker below than above; being eoneave posteriorly, where it rests upon the larynx, and convex anteriorly. The two lobes are eonneeted by a middle transverse lobe, termed the isthmus of the thyroid gland, but whieh is oeeasionally wanting.

The thyroid gland is bounded in *front*, by the sterno thyroidei and sterno hyoidei muscles; on the *sides*, by the platysmi myoides, sterno eleido mastoidei, and omo hyoidei museles; *posteriorly*, in the eentre it rests upon the lower part of the erieoid eartilage, and upper two or three rings of the traehea; but the lateral lobes rise as high as the inferior eornua of the thyroid; it is also bounded posteriorly by the eonstrictor pharyngis inferior, and the crico thyroidei museles: and its *edges* overlap the earotid sheaths, recurrent laryngeal nerves, and nervous filaments of the eervical ganglia, and on the left side the œsophagus.

It is *superiorly* bounded by the superior thyroideal arteries from the external carotid; and *inferiorly*, by the inferior thyroid branches from the subelavian arteries, as well as by large veins.

The thyroid gland has no proper eapsule, being surrounded by eellular membrane only: it it eomposed of irregular lobes, divided into lobules: in these is formed an oily yellow fluid, whieh fills the areolæ of the proper tissue, there being no apparent proper eavity. Oeeasionally vesieles, containing a whitish milky fluid, are met with, and without any appearance of disease. No exeretory duet has been discovered to this gland, or a suffieient number of absorbent vessels to give it the eharacter of an absorbent gland. It is very plentifully supplied by the four large arteries whieh have already been deseribed; but sometimes a variety oeeurs in the distribution of its vessels, in one large branch being given off from the arch of the aorta. The blood is returned not only by eorresponding veins, but by some large branehes, which pass downwards along the fore part of the traehea to terminate in the subclavian.

Its *nerves* are derived from the pneumo gastric and cervical ganglia.

Its *absorbents* pass to the jugular ganglia.

It sometimes happens that there is a variety in the position of this gland: it has been found so placed that its middle lobe passes behind the œsophagus, or between that tube and the trachea. Chronic enlargement, under such circumstances, might be productive of dangerous consequences. A narrow slip occasionally rises as high as the os hyoides; and in the infant, the lower part is always connected with the thymus gland.

The Trachea, or Wind-Pipe.

This tube commences from the lower part of the cricoid cartilage of the larynx, opposite to the fourth cervical vertebra, and extends to the lower part of the second dorsal or commencement of the third, where it terminates by dividing into the two bronchi. In this course in the cervical region, it is placed vertically; but when it reaches the chest, it takes a slight direction to the right. This tube is of a cylindrical form, being flattened posteriorly, and convex anteriorly. It is bounded *above*, by the larynx; *below*, by the bronchi; *anteriorly* and above, by the thyroid gland, by the inferior thyroideal veins, the sterno thyroidei and sterno hyoidei muscles; and lower down, by the thymus gland, left vena innominata, arteria innominata, and arch of the aorta; *posteriorly*, it is bounded by the vertebræ and by the œsophagus, which latter is rather to its left; and *laterally*, it is bounded by the carotid sheaths, and the recurrent laryngeal nerves; and just where it enters the chest, by the thoracic ducts.

At the termination of the trachea, opposite to the third dorsal vertebra, the *bronchi* commence resulting from the division of the trachea into a right and left tube, which pass to terminate in the lungs.

The *right bronchus* is larger, shorter, more horizontal, and somewhat anterior to the left: it enters the lung on a level

with the fourth dorsal vertebra and base of the heart. Just before it enters, it is crossed anteriorly by the right pulmonary artery, and posteriorly by the vena azygos.

The *left bronchus* is smaller, longer, and passes more obliquely than the right. Before it enters the left lung, the arch of the aorta partly encircles it, and the left pulmonary artery passes anterior to it.

The bronchi continue to subdivide into minuter branches, to be distributed throughout the substance of the lungs in ultimate structures, which are so connected with the arterial and venous systems, and are so minute, as to render a knowledge of these terminations obscure and unsatisfactory.

Organization of the Trachea and Bronchi.

These tubes, destined for the circulation of air in respiration, are furnished with cartilaginous rings to maintain their open state and to prevent the collapsing of their larger branches, with an internal mucous surface, an external fibrous sheath, and an abundant glandular and follicular apparatus.

The cartilaginous rings of the trachea are from sixteen to twenty in number: they do not encircle the whole tube, but leave the posterior third of its circumference open. They are thicker at their anterior part than at their extremities, pass around the tube in an irregular manner, though generally parallel, one above the other, in an horizontal direction, and terminate at the membranous posterior third of the trachea, in slight pointed angular portions, directed upwards. Occasionally one will bifurcate at the anterior convex part, or terminate before it reaches the posterior membranous portion. Anteriorly these rings are covered by a fibrous membrane, which continues from the inferior surface of the cricoid cartilage to the bifurcations of the bronchi, and internally by the mucous membrane lining the trachea.

The first portion of the bronchi is furnished with cartilaginous rings similar to the trachea, but they soon decrease in thickness and extent, becoming small detached portions,

which decrease until the tubes assume the appearance of arterial vessels: these ramify in all directions, until they terminate in what is termed the pulmonary lobule, which is said to result from the collection of several minute bronchial tubes, each of which terminates in a minute *cul de sac*, or air vesicle, and are held together by cellular membrane: thus constituting the proper parenchyma of the lung. Other physiologists state, that they terminate in cells belonging to the lung, independent of the bronchial tubes.

The internal mucous membrane of the trachea and bronchi is a continuation of the mucous lining of the larynx, and is supposed to extend to the ultimate divisions of the bronchi. It presents a slightly plicated appearance in a longitudinal direction, particularly where it lines the membranous portion of the trachea; it is there inclined to a reddish color, and is perforated by numerous follicles, which lubricate its surface with a viscid fluid.

External to this mucous lining, the trachea, where it is not occupied by the cartilaginous rings, is composed of a fibrous tissue formed of longitudinal and parallel fibres, the outer of which are redder than those which are most internal. This forms the whole of the posterior third of the canal; and, as it were, encloses the rings in its anterior part, passing from one ring to another in minute bundles, more apparent at the extremities of the cartilages, where they have been considered to be of a muscular structure. On the outer surface of this membrane, posteriorly, are situated numerous reddish, oval, mucous follicles, named the glands or follicles of the trachea: these have excretory ducts, which open internally upon the mucous membrane.

There are numerous small, dark-colored glandular bodies placed upon the fore part of the trachea and bronchi, more particularly at the bifurcation of the trachea. They are termed the bronchial glands, and will be found also to enter into the substance of the lungs: they are not furnished with excretory ducts, although they have been supposed to pour out a peculiar fluid into the bronchi; but absorbent vessels

may be traced to and from them, which afterwards terminate in the thoracic ducts.

The trachea is supplied with blood from the superior and inferior thyroideal arteries: its nerves are derived from the pneumo gastric and cervical ganglia.

The bronchi are supplied immediately from the aorta by two arteries named bronchial; their veins terminate in the vena azygos and superior intercostal; their nerves are given off from the pulmonary plexus.

Of the Lungs.

The lungs consist of the air-tubes and cells of the bronchi, of arteries, veins, absorbents, and nerves, held together by an extremely elastic tissue of cellular membrane, and enclosed within duplicatures of the pleuræ.

Their volume is always in proportion to that of the cavity of the thorax: for excepting the mediastína and their contents, the lungs completely fill this cavity, their volume increasing and diminishing with the motions of the thorax in the act of respiration.

Their figure also corresponds to the walls of the thorax, and may be described, therefore, as being conical: the base of the cone of each lung resting on the diaphragm, and the apex rising to the upper opening of the chest; besides which may be distinguished an anterior and posterior edge, an external and an internal surface.

The *anterior part* of each lung presents an acute edge, which is directed forwards and inwards, somewhat overlapping the pericardium; they are obliquely situated, passing downwards and forwards; and the left is notched to receive the apex of the heart. The anterior edge of one lung is separated from the other by the anterior mediastinum.

The *external surfaces* of the lungs are continued from the acute edge outwards and backwards to the posterior obtuse edges, presenting convex surfaces, corresponding to the concavity of the ribs; on these surfaces are observed the fissures which divide the lungs into separate lobes.

Each lung has one large fissure, which passes obliquely from behind to before, dividing the lungs unequally into a superior and anterior smaller and a posterior and inferior larger lobe. On the left side the apex of the heart is received into this fissure.

On the right side, the superior lobe is subdivided by a second fissure, which passes obliquely from the great fissure in a direction upwards and forwards, and thus divides the right lung into three lobes.

The *posterior edges* are thick and rounded, corresponding to the concavities formed by the articulations of the ribs with the vertebræ, and are separated from each other by the posterior mediastinum and its contents.

The *internal surfaces* of the lungs are irregularly concave, corresponding to the form of the heart, and in their centre the bronchi and pulmonary vessels enter, constituting the roots of the lungs; posterior to which these surfaces are separated from each other by the posterior mediastinum, and anteriorly by the pericardium, anterior mediastinum, and thymus gland.

The *bases* of the lungs are concave, resting upon the upper surface of the diaphragm; the base of the right, on account of the ascent of the diaphragm, is more concave and broader than the base of the left, which latter has, from this circumstance, as well as from the obliquity of the anterior mediastinum, a greater vertical dimension than the right lung, but on the whole is somewhat smaller.

The *apices* of the lungs occupy the upper part of the thorax, and are capable, during a forced inspiration, of rising through the upper opening of the chest into the cervical region.

Organization of the Lungs.

The parenchyma of the lungs is principally constituted of the termination of the bronchial tubes, which are held together by a highly elastic cellular membrane: besides which they contain the ramifications of the pulmonary arteries and veins, the bronchial arteries and veins, numerous absorbents,

and the nerves of the pulmonary plexus; the whole being surrounded by the pleuræ pulmonales.

Having already described the ultimate divisions of the bronchi we may here remark, that there is a difference of opinion respecting the nature of the cells they form: some supposing that both the fibrous external, and the mucous internal membrane, are continued to their ultimate divisions, although in an extremely attenuated form; while other physiologists assert, that the mucous membrane ceases before the formation of the air-cells, around which the blood is consequently brought into closer contact with the inspired air than it would be with the intervention of the mucous membrane and its secretion. This theory is strengthened by the fact, that in bronchitis the air-tubes generally contain pus, while it is very rarely found in the air-cells: from this an opinion has been formed, that the air-cells belong to the structure of the lungs themselves, independent of the bronchial tubes.

The distribution of the pulmonary *arteries* is similar to that of the bronchial tubes, accompanying them from their larger branches to their minutest terminations.

The *veins* are supposed to commence from the ultimate capillary terminations of the arteries; but both the terminations of the arteries and the commencement of the veins are involved in that obscurity which such minute structures necessarily create, from our inability to view them even with our best microscopical instruments. Some assert that the arteries and veins anastomose upon the air-cells; others, that the artery terminates, and the vein begins by open mouths within them. The fact of their intimate connection is established by the course of injections; which, whether thrown in from the bronchi, artery, or vein, reciprocally fill each other.

The *bronchial arteries* distributed for the proper nourishment of the substance of the lungs are very various in their number and origin; they usually arise from the aorta, either by one or more branches; at other times, the right bronchial

artery is derived from the first intercostal. When they enter the lungs they take the course of the bronchial tubes, accompanying them to their ultimate division. The *veins* which return the blood of these arteries do not correspond to them in their course; and a great variety of opinions exist relative to their termination, as some have described them as opening not only into the vena azygos, superior cava, subclavian, and intercostal veins, but also partly into the pulmonary veins, which would be a circumstance quite unlike what occurs in any other part of the body, as we should have the venous blood conveyed at once into the arterial circulation without having been purified by the contact of the air.

The *nerves* of the lungs are derived from the pulmonary plexus, formed by the pneumogastric and sympathetic nerves; which plexus, around the bronchi exterior to the lungs, produce numerous interlacements, and within their substance are indiscriminately distributed both to the bronchi and pulmonary vessels.

The *absorbents* are divided into a superficial and deep seated set: the superficial ramify beneath the pleuræ, and terminate in the bronchial glands, at the root of the lungs; the deep seated pass along the course of the veins, through the bronchial glands, and emerging from the chest, they terminate in the thoracic duct of their corresponding sides.

Physiology of the Larynx, Trachea, and Bronchi.

As these air-tubes are equally concerned in the production of the voice and the function of respiration, it will be necessary to consider their physiology under separate heads, and first—

Of the Physiology of the Voice.

The voice is produced in the larynx by its mechanical operation upon the air passing through it, much in the same manner as sounds are emitted from wind instruments; these sounds are variously modified, not only by the larynx itself, but in the direction they are made to take in their progress

through the mouth and nasal passages, by the appropriate motions of the lips, lower jaw, tongue, pharynx, and fauces, as well as by the length of the trachea.

Speech is an acquired faculty, resulting from the appropriation of certain sounds emitted by the voice to express our ideas. The sounds constituting speech are infinitely numerous, as may be seen in the various languages and dialects of different nations.

The sounds of the voice, and their innumerable modifications, may be considered under three heads: natural, imitative, and musical sounds.

Natural sounds belong to all animals that have lungs; and may we not add the "voice of the cricket," though made by the motions of its wing and leg, the hum of bees, and various other sounds produced by insects.

The cry is the earliest natural sound, and establishes a remarkable instinctive intelligence between parent and offspring. Thus it readily expresses pain and fear, and will incite the almost defenceless hen to face the ferocious mastiff, in aid of her little ones in danger. The cry expresses the most simple wants, and natural passions; and this sort of language is found in most animals. In man it belongs to all ages and states: the infant and the aged, the savage and the civilized, the idiot and the person born deaf, all have the faculty of crying. It expresses many of our most vivid feelings: thus there is a cry of rage, of fear, of pleasure, and of pain.

Imitative sounds form the basis of all languages: hence speech is never acquired without the aid of the sense of hearing. Persons born deaf are also dumb, so far as the faculty of speech is concerned; for the simple reason—because the ear is unable to appreciate the sounds which are employed in language to express objects and ideas. For the same reason, a person who hears badly, is often inclined to speak high; or, having a false ear, has also a false voice: and those born deaf, who have been taught artificially to speak, have voices hoarse, dull, and with unequal inflections.

Young children begin by imitating the sounds they hear, in a very imperfect manner, being only capable of expressing those which are the most simple. In their early attempts they frequently substitute vowels, and sounds easy of expression, for names which are in any way complicated or harsh: so also in their first attempts to construct a sentence, their errors are all simplicity, and are regulated only by careful education, and the force of correct examples.

Nothing proves speech to be the result of imitation, regulated by civilized education, more than the existing varieties of language among different nations, as well as the peculiarity of dialect in different parts of the same country.

Rhetoricians have entertained various opinions respecting the origin of languages, which would be superfluous to consider here, as indeed they have been in general too speculative to have led to any useful conclusion.

The modifications of the voice are expressed in letters; and these, variously combined, form words, which are the signs of ideas, and the component parts of language.

The letters or alphabet are pronounced by varying the mode in which the voice is emitted: some letters, being quite simple, require hardly any action beyond the larynx itself: others require the motion of the tongue acting with its tip, middle, or base; others of one or both lips; while for the production of some, the air is made to pass the nasal cavities. Indeed, a clear pronunciation of any sound is not made when either from disease, or artificially, the nasal cavities are closed. The air, in its passage through the mouth only, appears to be arrested, and to impart a thickness to the voice; or, what is improperly termed, speaking through the nose.

The letters have been divided by grammarians into vowels and consonants; but, in a physiological point of view, we rather consider the mechanism by which they are pronounced. Thus the letters in all European languages, consist of those which are purely vocal, and are pronounced with very little effort: these are *a*, *e*, *i*, *o*, *u*, named vowels,

and proceed entirely from the larynx, subjected however to numerous modifications, depending on the force with which they are uttered, producing long or short accents. So also we have, as enumerated by Majendie, *a* very open, as in *hall*, English; *â*, in *hâle*, French; *a, é, è* and *e* mute, French; *i, o*, open, Italian; *o, eu, u*, French; *u*, Italian. Other vocal letters are *b* and *p*, labial; *d* and *t*, dental; *l*, palatine; *g* and *k*, guttural; and *m* and *n*, nasal consonants. The other letters are *f* and *v*, *th*, English; *s* and *z*, *ch*, *j*, *r*, *h* and *x*, Spanish; *χ*, Greek; and are produced chiefly by the air being forced against the sides of the mouth, and directed by the tongue, either by its tip, middle or base: *v* and *f*, by the lower lip and upper teeth: *r*, in English, has a much softer sound than in French, where it is pronounced by a vibratory motion of the tongue against the roof of the mouth.

Words are compound sounds, formed by the combination of letters; and being arranged according to the rules of grammar, constitute a language.

Languages are more or less harmonious, in proportion to the number of vowels or simple tones which it contains: thus the Greek and Latin, among ancient languages; and among modern, the Russian, Italian and Spanish are more agreeable than those of teutonic origin, as the French, English, German, Dutch, Sweedish, Danish, &c.

Speech, considered as the means of communicating our thoughts, is the organ of our intellectual faculties: and herein constitutes the great superiority of man over the rest of the animated creation. He alone can express his feelings in appropriate language; can accumulate knowledge in the storehouse of his memory; can search for causes, and distinguish effects; and, above all, can judge and reflect upon the past, the present, and the future.

The third class of sounds produced by the voice is musical sounds, or vocal harmony.

Singing requires greater exertion than is used in speech, and the organs of voice are called into more varied as well as more powerful action. Thus the trachea is lengthened

or shortened, by the stretching out, or drawing in of the neck; inspiration is accelerated, prolonged, or slackened; the larynx rises or descends; while the glottis is made to enlarge or contract, either by sudden and quick, or slow and gentle motions. Singing, therefore, consists of modulations of the voice; imitating, with varying rapidity, the different degrees of the harmonic scale; passing from grave to the acute, and from acute to the grave, in sounds which are appreciable by the ear, and regulated by the rules of harmony.

The powers of the human voice are very extensive, and vary remarkably at different ages and in different individuals. The characters of voices are distinguished by the names grave, acute, high, counter, tenor, base, falsetto, &c. We have already compared the voice to a musical instrument, in which the air is made to vibrate as in wind instruments: such, for instance, as the clarionet. In this a thin plate is made to vibrate, intercepting and allowing by turns the passage of a current of air, by which sounds are produced: this structure, termed the reed or anche, is fixed to a tube or body. If the plate is long, the sounds are grave; if short, acute, owing to the greater rapidity and strength of the vibrations in the short than in the long plate. The tube or body has no other influence on the sound produced, than upon its loudness or intensity: those which produce the loudest sounds are of a conical form, increasing in width towards their outer end: if the cone is inverted, a dull sound is produced; but if two equal cones are placed base to base, and adapted to a conical tube, as in the flageolet, the sound acquires fulness and power.

The larynx has been compared to different musical instruments by different physiologists. By Galen, to the flute; Dodart, to the horn; Ferrein, to the reed instrument: but it is considered at the present day to partake of the powers of both wind and stringed instruments, and capable of being regulated by vital action. The quantity as well as the force with which the air is propelled through the larynx, variously

contributes to the loudness of the voice: these circumstances are regulated by the size and muscular power of the chest, the volume or size of the larynx, and the power of its proper muscles. In singing, the larynx acts the part of the reed, while the trachea answers to the tube: thus, in running up or down the whole scale of sounds, the neck and trachea are visibly shortened or stretched out.

Acute and grave sounds are produced by the motions of the rima glottidis, regulated by the tension of the vocal cords and their vibrations, as they are variously stretched by the muscles in the peculiar mechanism of the larynx. In grave sounds, Magendie observed in some experiments on dogs, that the air passed out through the whole length of the glottis, the ligaments vibrating in their whole extent. In acute sounds, only the posterior or arytenoid portion of the ligaments vibrated; and in proportion to the diminution of the opening of the glottis, so was the acuteness of the sound. The arytenoid muscles are those which principally produce these acute sounds, as is proved by the division of the superior laryngeal nerve which supplies them; and when divided, they establish a grave tone. It is therefore readily seen how much depends upon the consent of the muscular actions of the larynx, and the consent of the will, in exciting a due degree of tension and relaxation. A sound is readily produced in a larynx when blown into out of the body, and which will be similar to the voice of the animal to which it belonged, but different from that produced during life, in consequence of the want of that regulation which is produced from the tension of the vocal cords during life. Independent of these sounds, each individual has a particular tone of voice, which is readily detected by those who are accustomed to hear it. The same thing occurs among animals: in the same flock of sheep, each ewe and its own lamb are attracted by each other's bleating, and not by those of others.

The voices of women, children and eunuchs are more

acute than those of men, from the comparative smallness of the larynx: it becomes weaker also during illness, from the loss of power in expiration.

The whisper is produced in a similar manner by a weakened action, in which the sound is not more audible than that produced by the passage of the air in forced respiration.

The larynx remains small until the age of puberty, when a remarkable change takes place: the cartilages of the larynx are then enlarged, and the voice sinks generally about an octave. This change is frequently a whole year before it is completed; during which time the voice is said to moult, or to be broken. Occasionally the voice, during this period, will be nearly lost for some weeks, or contract a disagreeable hoarseness: sometimes acute sounds are involuntarily produced instead of a grave one; and the power of singing, and producing appreciable sounds, is for the time wholly lost. This continues until the larynx is fully developed, the glottis is lengthened, and the pomum Adami projects forward. In the female, this change in the glottis at puberty is not apparent, and the voice remains acute.

In old age the voice is weakened from the loss of muscular power, and the want of the teeth: the voice is then much altered, and the pronunciation is frequently changed.

Considered as a musical instrument, the powers of the voice are greater, and infinitely more varied, than those of artificial instruments: it imitates all languages, and produces the most powerful expression of passion, particularly those of love and adoration, and in the highest intellectual pleasures.

We have yet to mention the deception practised by the art named ventriloquism, in which the voice appears to come from distant objects, and not from the actual speaker. This art has been named from the supposition that the voice came from the stomach, and that the ventriloquist had the power of directing it to any place at pleasure; but the fact is, that it is founded entirely on imitation. The ventriloquist, gifted

with a genius for mimicry, observes the effects of various sounds produced at different distances; that they become feeble, less distinct, and that their expression changes: these he carefully imitates: deceiving the spectator, by directing his attention to the spot from whence he is to suppose the voice really issues. Thus the voice from behind a door, from a chimney, or down in a cellar, are such as are generally chosen for successful imitation; at the same time the ventriloquist chooses words which he can pronounce without moving his lips, rejecting as much as possible the labial consonants.

Function of Respiration.

The most obvious result in the process of respiration, is the change of venous into arterial blood: in which we have to observe, first, the alterations effected in the composition of the air respired; and, secondly, by the effects produced in the condition of the blood. For these purposes, respiration consists of an alternate succession of inspiration and expiration, during which the venous blood is exposed to inspired air in the air-cells of the lungs; and having also undergone the operation of the vital influence of these organs, is returned to the heart and general circulation of the body; while the air, which has undergone the action in the lungs, is expelled in expiration.

The great necessity for the constant continuation of this function, and its important purposes in the animal economy, is evinced by the fact, that the suspension of respiration, even for a few minutes, destroys life. It is not, however, so clearly obvious, wherein the changes produced in the blood, and the action of the atmospheric air in effecting these changes, consists; and there are still many phenomena in this important function which have not been satisfactorily explained.

In order to take a concise view of our present knowledge upon this interesting subject, I shall consider it under the following heads.

1.—The nature and properties of the atmospheric air.
2.—The volume of air respired.
3.—The changes effected in respired air.
4.—The changes produced in the blood.
5.—The connection of respiration with the production of animal heat.

1.—The atmospheric air is a compound gaseous body, surrounding the earth to about the height of forty-five miles, and revolving with it round the sun: according to the theory of Herchel, being confined to the earth by the force of the attraction of gravitation. It is composed of the proportion of 20 or 21 oxygen to 79 or 80 nitrogen in 100 parts by measure; while in the same quantity by weight, there are 23 parts of oxygen to 77 of nitrogen, which shows that the oxygen is rather heavier, and the nitrogen rather lighter than its own bulk of the compound: to these are added a variable quantity of carbonic acid, and more or less water in the state of vapour. According to some late experiments of Theodore Saussure, 10,000 parts of atmospheric air contain 4.9 of carbonic acid as a mean, 6.2 as a maximum, and 3.7 as a minimum.—(*An. de Ch. et Ph.* xxxviii. 411.)

Of these constituents, oxygen is the principal agent, and imparts the chief of the chemical properties possessed by the air. In the animal economy it is highly stimulating, and its presence is indispensable in the process of respiration. It must indeed not only be present, but in a certain quantity; for it appears that the more perfect animals cannot exist in an atmosphere which contains less than one tenth of its weight of oxygen: the molusca, however, have the power of depriving any given quantity of air of every particle of this gas. Although oxygen is necessary for the support of respiration, yet in a state of purity it is deleterious, as is proved by immersing animals in this gas. At first, no inconvenience is perceived; after an hour, their respiration becomes rapid, there is high excitement; then great debility comes on, and continues increasing until the animal dies.

Nitrogen gas is irrespirable, although it exerts no evident

injurious effects either on the lungs or on the system at large; it however destroys life, by depriving the system of the presence of oxygen. Its use in the atmospheric air, and the exact purpose it performs in the animal economy, are not clearly known. Chemists have supposed that it performs the office of a diluent to neutralize the too stimulating effects of the oxygen gas; but how far this is really the case remains yet to be discovered.

Carbonic acid gas is like nitrogen, irrespirable; not only destroying life, by depriving the system of oxygen, but it excites a spasmodic action of the glottis, by which it closes so forcibly, as to prevent the entrance of the last portion into the lungs. It is constantly met with in the air of every part of the globe, whether from the lowest or the highest situations which have been hitherto attained.

The atmospheric air, consisting of the above named ingredients, is in all probability the only gaseous compound which is capable of being respired for any period, so as to answer all the purposes required in the animal economy. Its physical properties are, great elasticity and compressibility; whence arises a greater density in the air at the surface of plains or valleys, than on the summits of high mountains; the weight of the superincumbent atmosphere being greatest in the former situations.

We are not sensible of the weight of the atmosphere pressing on our bodies, because it is applied at all times, and in every direction, with a perfect equilibrium. There can be no doubt, however, of the fact, that a column of air, only one inch square, the height of the atmosphere, weighs about fourteen pounds: calculating that the surface of the body in a man of middle size is fifteen or sixteen square feet, it will follow that he sustains a weight of atmosphere equal to thirty-six thousand pounds. Many important purposes are answered by the pressure of the atmosphere: the fluids we now possess would all be converted into gasses, and even solids might become fluids, if the pressure of the air should be removed. The phenomena of venous circulation

has been attributed to the pressure of the atmosphere by Dr. Curson and Dr. Barry; but their theory, of a partial vacuum being formed within the thorax, has many objections.

The weight or pressure of the atmosphere is variable, as its density is liable to alteration from different degrees of heat and other causes accompanying the changes of the weather. The variations of the weight of the air are indicated exactly by the barometer. At the temperature of 32° F., and the barometer at 29½, the weight of 61 cubic inches of air is twentry grains; the same volume of water, 15,444 grains: hence air is 770 times lighter than water.

Water combines readily with air, and this combination is rapidly increased by the aid of heat: cold, on the contrary, causes the water to separate from the combination, and is precipitated in the form of mist, fogs, rain, hail or snow.

The color of the air is blue, transmitting all the rays of light excepting the blue which it reflects: hence distant objects are tinted blue in proportion to their distance, when the air is clear.

2.—In order clearly to ascertain the chemical changes effected in the process of respiration, it is first necessary to estimate the volume of the air respired. Various observations and experiments have been made to ascertain this point; but as it depends upon the force employed in respiration, upon the habit of the individual, and still more upon the capacity of the chest and other varying circumstances, much difficulty has been experienced in forming any satisfactory conclusion. Three different degrees of respiration have been enumerated by physiologists: the ordinary, the forced, and the violent.

The ordinary respiration occurs during sleep, or in a state of bodily rest: in this degree the diaphragm is simply depressed, and the elevation of the thorax is almost insensible.

Forced respiration occurs during bodily exercise, or mental excitement, when the thorax is evidently raised, at the same time the diaphragm is depressed.

Violent respiration is occasioned by violent exercise, or imperfect action of the lungs: here all the muscular powers of respiration are called into action to dilate the thorax in every possible direction, as far as the physical disposition of this cavity will permit.

The number of respirations in a minute also varies in different individuals: Sir H. Davy respired twenty-six or twenty-seven times in a minute: Hales, twenty; and Dr. Thompson, nineteen: Menzies, fourteen; Majendie, fifteen: I respire eighteen. From hence the range is between fifteen and twenty-seven, and is usually accompanied by four pulsations of the heart to each respiration.

A still greater discrepancy occurs in the estimation of the volume of air which is breathed at each inspiration. Sir H. Davy estimates it at thirteen to seventeen cubic inches: Messrs. Allen and Pepys, at sixteen and a half: Mr. Kite, at seventeen: Mr. Abernethy, twelve; and Thompson and Menzies, at twenty.

The lungs of a stout man after death were found to contain 100 cubic inches, of which 31.58 were expelled by the resiliance of the lungs upon opening the thorax. Dr. Menzies observed the power which individuals possess of forcing an additional volume of seventy cubic inches in one inspiration: hence he estimates the range between an extreme expiration and an extreme inspiration, to exceed 200 cubic inches: Dr. Bostock, from several experiments performed on himself and others, at 160 or 170; to which he adds 120 as the residual air in the lungs, together making the natural volume 290.

Dr. Thompson thinks a fair mean would be, to estimate the ordinary quantity of air in the lungs at 280 cubic inches; forty of which enter, and go out at each respiration. Then calculating twenty inspirations to a minute, there would be 800 cubic inches respired in a minute, 4,800 in an hour, and 1,152,000 in twenty-four hours.

3.—We come now to enquire what changes are produced in the air, and what and how much of it is consumed in the

process of respiration. The changes produced are an increase in the proportion of carbonic acid, and a variable loss of oxygen and nitrogen.

It was at first concluded from the able experiments of Allen and Pepys, that the quantity of oxygen lost, exactly equalled the quantity of carbonic acid produced; and hence, that the function of respiration consisted simply of the separation of carbon from the blood, and its union with oxygen in the lungs forming carbonic acid.

Subsequent experiments, however, have proved, that the consumption of oxygen is greater than is necessary for the formation of the carbonic acid gas expired; and that this varies from the proportion of one third of the volume consumed in the formation of the carbonic acid gas, to almost nothing. This variation has also been found to depend upon age, peculiarity of constitution, the species of animal employed; and it also varies in the same individual at different times. It is increased during exercise, digestion, and periodically during the twenty-four hours. Dr. Prout estimated these variations at 4.1 per cent. of oxygen inspired about noon, 3.3 per cent. towards eight o'clock in the evening; from which time to half-past three in the morning there is no change. Dr. Bostock has estimated the whole bulk of oxygen consumed in twenty-four hours, under ordinary circumstances, at 45,000 cubic inches; and the carbonic acid produced in the same period, at 40,000 cubic inches: Messrs. Allen and Pepys, at 39,534 cubic inches: a quantity equal to eleven ounces troy of solid carbon in twenty-four hours.

Subsequent experiments have also shown that a portion of nitrogen is occasionally lost, as well as oxygen; and in certain instances, a portion of nitrogen is generated. This last occurs in young animals; and is increased during the spring, and decreased during the winter. Sir H. Davy found, by repeated trials, that five cubic inches of nitrogen were consumed in a minute, making upwards of 7,200 grains in twenty-four hours. Allen and Pepys have endeavoured to prove that nitrogen was given out during respiration; while

others, again, believe there is no alteration made in the quantity. It has been most indisputably proved by Spallanzani, that nitrogen is absorbed during respiration by reptiles generally: and Humboldt and Provençal have lately ascertained the same fact with regard to fishes.

Some doubt has been thrown on the fact of the production of carbonic acid in respiration, through the union of the carbon of the blood with the oxygen of the air. By some experiments performed by Dr. Edwards, he found that frogs and kittens immersed in pure hydrogen during eight hours, generated as much carbonic acid as when breathing atmospheric air during twenty-four hours: from which he concludes, that there is a possibility of carbonic acid being wholly generated in the lungs. The exact source, therefore, of the carbonic acid produced in the process of respiration, is still a matter of controversy. It is not clearly ascertained whether the venous blood absorbs oxygen in the lungs, or whether it merely gives off its superabundant carbon, which unites with oxygen, forming carbonic acid in the lungs themselves: thus making the essential difference of being formed within or without the blood-vessels. That both these processes may go on simultaneously, is also by others admitted; that is, that a portion of carbonic acid gass is given off, ready formed, from the blood, together with a portion of free carbon; or, as has been supposed, in the state of an oxyde or hydrate of carbon, which combines, with an additional quantity of oxygen in the lungs, the whole of the cabonic acid formed arising from these two sources. At the same time there is a portion of oxygen absorbed, which combines with the carbon in the blood, to generate the oxyde of carbon or the carbonic acid discharged from the blood in the lungs. The experiments of Dr. Edwards certainly prove the possibility of carbonic acid being secreted or eliminated in the lungs independent of the absorption of any oxygen from the air. Another experiment has been made, which seems to point out the possibility of oxygen being met with in the lungs in a state favorable to combina-

tion with substances in the circulation. The experiment consists in injecting phosphorus, dissolved in oil, into the veins of a dog; when the phosphorus will be expelled from the mouth and nostrils in the form of copious white fumes of phosphoric acid; which would seem to prove, that the phosphorus, in a state of infinite division, met with oxygen in the lungs, and there formed the phosphoric acid. If this is admitted in the one case, it is equally applicable to the other—in the formation of carbonic acid gass.

The real quantity of air is supposed neither to be lost nor increased during respiration; and that only a chemical change is produced. Sir H. Davy, however, considered that about 1-100th part of its bulk was consumed; and when air was repeatedly respired, the loss, according to him, became proportionally greater. It must therefore be confessed, that we are yet unable to draw any certain conclusion respecting the exact nature of the changes produced in the air by the process of respiration.

Connected with this part of the subject, it is right to mention, that the air is not the only gaseous respirable substance, although probably the only one which could be respired with impunity for any length of time. Of the different gasses, carburetted hydrogen, sulphuretted hydrogen, carbonic oxyde and nitrous gas, occasion immediate death by their specific action on the blood: hydrogen and nitrogen occasion death simply by depressing the system: of oxygen, carbonic acid, and probably acid and alkaline gasses in general, are wholly irrespirable, the glottis closing spasmodically from its mere contact only. When pure oxygen is breathed, about 100 per cent. of carbonic acid is produced; and a portion of nitrogen, equal to a similar portion of oxygen, lost.

It will be found that the function of the lungs is intimately connected with the functions of other organs: and particularly with the skin, in respect to the formation of carbonic acid. In hot climates, this is found to be more abundantly formed from the skin than in cold climates,

and more abundantly from the skin of the negro than the European: and at the same time that it is greater in the skin, it is less in the lungs: hence the skin is capable of performing a vicarious office to the function of respiration.

An aqueous vapour is produced in respiration, which is supplied from the membranes of the mouth, fauces, larynx, trachea, and bronchi: its quantity has been variously estimated: Dr. Hales, at twenty ounces in twenty-four hours; Dr. Thompson, nineteen ounces; Mr. Abernethy, nine; Dr. Menzies, six. Majendie found this to be variously modified by changes in the state of the blood.

4.—The changes produced in the blood, resulting from respiration, are numerous, as may be seen from the following table.

	Venous Blood.	*Arterial Blood.*
Color	Brown red	Vermillion red.
Odour	Weak	Strong.
Temperature	101-75° F.	Near 104° F.
Capacity for caloric, water being 1000	852	839.
Specific gravity, water being 1000	1051	1049.
Coagulation	Less rapid	More rapid.
Serum	More abundant	Less abundant.

The change of color in the venous blood is evidently owing to its contact with oxygen, as may be proved, first, by depriving venous blood of contact with the air, when this change will not take place; but either out of the body, or by artificial inflation in the dead body, this change of color readily takes place: a bladder containing venous blood, and immersed in oxygen gass, will allow of this change, through its parieties; from whence we may learn, that venous blood may absorb oxygen through the parieties of the air-cells of the lungs; and still more readily the change is produced when blood is exposed to pure oxygen. How oxygen produces this change of color is not so easily ascertained: that it is through the agency of the iron in blood, Majendie

considers to be likely; and states, that when the blood is deprived of its iron, the property of becoming scarlet, from contact with oxygen, is lost.

5.—The evolution of animal heat is a process which appears to be intimately connected with respiration, and the change of venous into arterial blood: but probably from the same reason that we are unable clearly to point out the exact process, by which oxygen is made to combine with carbon to be expired in the form of carbonic acid gass, we are as yet ignorant of the precise nature of the evolution of animal heat. The intimate connection of this process with the function of respiration, may be inferred:—First, from the size of the lungs in different animals being commensurate with the habitual temperature of their bodies. Thus, in all cold blooded animals, the respiratory organs are small, and therefore consume but a comparatively minute quantity of oxygen, and generate but little carbonic acid, their temperature being chiefly influenced by the change of seasons, and varying state of the *media* in which they exist. In warm blooded animals, on the contrary, where the respiratory organs are large, and the chemical changes are more abundant and complete, the temperature is almost uniform; and is highest in those which have the largest lungs in proportion to the size of their bodies, and consume the greatest proportion of oxygen. Secondly, from the connection of the temperature, and the state of respiration, in the same animal at different times. Thus when the circulation is slow or incomplete, as in various states of disease, and in malformation of the heart, the temperature is low, and the arterialization of the blood is imperfect. So also, when the body of an animal is immersed in a warm atmosphere, so as to require but little heat to be generated, the consumption of oxygen is unusually small, and the blood within the veins retains the arterial character. Thirdly, in young animals, the power of generating heat depends upon the power they possess of consuming oxygen; as may be seen by the experiments of Dr. Edwards, who has remarked that some young animals, as puppies and

kittens, require so small a quantity of oxygen for their support, that they may be deprived of it altogether for twenty minutes without injury; but, at the same time, their temperature sinks rapidly by exposure to the air; while as they grow older, and are able to maintain their own temperature, this power of existing without the presence of oxygen ceases. These observations equally apply to birds, some of which are naked when hatched, and are, similar to puppies and kittens, capable of existing, deprived of oxygen, for a considerable time, depending principally on their parents for the support of their warmth; while others, as young partridges, who quit their shells fledged, and are thus enabled to maintain their own temperature, die from deprivation of oxygen as rapidly as adult birds.

These facts sufficiently prove the intimate connection which exists between respiration and the evolution of animal heat: it is, therefore, not improbable that sensible heat is given out in the combination of carbon with oxygen, the same as in every other instance of the union of oxygen with a combustible body; but then we are not warranted in considering this function as a mere chemical process, its connection with vital or nervous influence must be admitted; and herein may it not be considered to resemble the function of digestion, and other processes purely vital, in which a chemical influence is controled or modified by living or nervous influence.

Sir Astley Cooper found, when trying some experiments to ascertain the comparative heat of arterial and venous blood, that a thermometer, placed in the ventricle, rose when the animal was violently agitated, and fell when it was at rest, and the agitation subsided,—which would strengthen the supposition that animal heat is greatly promoted by the direct action of nervous influence.

Facts of such importance, that they cannot be wholly rejected, have been adduced, both by those physiologists who consider the evolution of animal heat as a mere chemical process, and by those who ascribe it solely to the influence of the nervous system.

The fact, that carbonic acid gas is generated, and apparently in proportion to the quantity of oxygen consumed, can scarcely be doubted; and that the process of respiration is the chief source of the consumption of oxygen, as well as the exit of carbonic acid gas.

According to the theory of Crawford, heat depends upon the different capacity for caloric between arterial and venous blood, being in the ratio of 104,5 to 100, hence forming a latent principle in arterial blood, to be given out as it flows through the system, and changes to venous blood. Mr. Brodie ascertained, from his experiments, that artificial respiration may be maintained in a decapitated rabbit, and all the changes of venous to arterial blood effected; the same deterioration of the air takes place, without the least increase, but rather with a diminution of temperature, the animal being cooler, by one degree, than another rabbit in which no such arterial change was effected,—from whence he infers that animal heat is independent of respiration, and must depend upon nervous influence altogether.

Another experiment has been tried, which proves that arterial blood may, by means of galvanism, be made to assume the venous hue, and at the same time to give out heat. The trial was made with the blood of a rabbit, immediately upon being drawn; upon applying the galvanic influence, an evolution of heat, amounting to 2° or 3°, took place: no rise of temperature could be produced in venous blood by the same means. From the whole it must be confessed, that this department of physiology requires more research, and a careful repetition of many of those experiments upon which the theories of Crawford, and others, have been supported; and particularly with due regard to the temperature of the air inflated, and the natural temperature of the animals employed. The great uniformity in the heat of the blood, in all ages and in all climates, is a circumstance no doubt connected with many of the phenomena yet unexplained. Mr. Brodie's and Dr. Davy's experiments have certainly shewn, that Crawford's theory of the production of animal heat is not, as he

supposed, the mere chemical result of the difference of capacity for caloric on one hand, between carbonic acid and oxygen, and on the other, between arterial and venous blood. Still, when the nervous influence of the brain is in full action, who can say such changes may not actually be carried on, or if the evolutions of animal heat does not wholly depend upon a reciprocal action between the nerves and the arteries, which the decapitation annihilates. In local diseases there is frequently an increased local temperature, greater than the mere increase of circulation in the part is able to explain; the common occurrence of such increased temperature in the hand, from exposure to cold, independent of disease, can hardly be accounted for, unless we admit other sources of animal heat, independent of the pulmonary circulation, but of which the *modus operandi* has not been discovered.

Connected with the evolution of animal heat, there is a circumstance attending it that is particularly worthy of notice in the progress of experiments: which is, that sensible heat is variously experienced in certain states of mental agitation, and the progress of febrile affections; the skin feeling cold to the individual, while it is actually hotter to the touch of another person, and *vice versa*. Are these states realities or a mere deception, depending on disease? If a reality, may it not depend upon a peculiar vital action, rendering the latent caloric sensible, previous to its being given out in a free form on the surface of the body.

Practical Remarks.

There are numerous diseases and accidents incident to the larynx and trachea, which render a surgical operation necessary for the formation of an opening in the air-tube, for the admission of the air in respiration. The technical term given to this operation was formerly bronchotomy, in whatever part of the tube the opening was made; but of late years the term laryngotomy and tracheotomy has been adopted, to designate the precise point at which the operation is performed.

The causes which render these openings necessary are those which form obstructions to the free passage of the air in respiration: such as thickening of the mucous membrane of the larynx and trachea, or sub-mucous tissue in the progress of acute or chronic inflammation; the

depositions of adventitious membranes, as in croup; pressure from external tumours; enlargement of the tonsils or the tongue; the pressure of extraneous bodies passing through the glottis, or sticking in the œsophagus; gun-shot wounds; and wounds from arrows or other pointed instruments penetrating the air-tube: each of these circumstances, by obstructing the respiration, occasion such urgent symptoms, that immediate steps must be taken to prevent suffocation.

It will be readily seen, that although the object is the same in each of these cases,—to establish a free access of air to the lungs,—the causes are so different, that they require considerable variation in the means which are necessary to be adopted. For instance, when, from idiopathic causes, the object is not only to relieve the patient from the immediate danger of suffocation, but to establish a passage during the process of cure; and when, from the presence of a foreign body in the trachea, such an opening must be made as will be necessary to effect its abstraction; but still greater differences may be required in obstructions arising from either tumour or foreign bodies lodged in the œsophagus, so as to press upon the larynx or trachea.

When the object is merely to establish a free passage of air, it may be attained by the introduction of a canula into the larynx or trachea; which instrument, by exactly fitting the opening which it makes, has the advantage of preventing any hæmorrhage from entering the bronchi. Various modes of performing this operation are recommended: by some, a canula and trochar are at once thrust into the part; but this is objectionable, on account of the force which is required in penetrating the skin and parts underneath, and from the danger of passing the trochar so far as to wound the posterior parts of the wind-pipe. In tracheotomy, an incision should therefore always be first made through the common integuments and cellular membrane, to the extent of from two to three inches, extending from half an inch above the centre of the sternum, to a little above the cricoid cartilage in the central line of the neck. The skin should then be drawn aside with bent probes; and if any vessel appears exposed to the knife, it should be drawn aside in a similar manner. The incision is then to be continued between the sterno hyoidei muscles to the fascia which covers the trachea, within which it will be seen to slide up and down, in proportion to the violence of the efforts in respiration. A portion of this fascia should be removed, either with a knife or a pair of scissors, to secure the correspondence of the opening in the trachea to the external incision, and to facilitate the introduction of the canula. The trachea will now be in view; and when there is an irregular distribution of the blood-vessels, the large thyroid vein may here interfere, and must be avoided. All hæmorrhage, when time permits, should now be carefully secured; and the

surgeon should wait until even that from the sides of the wound is stopped, in order, as much as possible, to prevent the passage of any blood into the trachea, which would accelerate suffocation. It is generally recommended, that the head should be thrown as far back as possible, in order to extend the anterior part of the neck; but this must be done with caution; for when the parts about the larynx are thickened, this bending of the neck may so increase the obstruction, as in itself to cause suffocation before the operation is completed. The canula and trochar may now be introduced, either between the rings of the trachea, or a small portion of one of the rings may be cut out, so as nicely to fit the introduction of the canula: to do this, a small slit should be made in the cartilage of the trachea, so as to permit the introduction of a hook or forceps to lay hold on the part to be removed. When the membrane lining the trachea is first punctured, or canula introduced, it generally occasions great uneasiness; which, however, quickly subsides. The canula is secured by a tape around the neck, and a piece of fine muslin should be placed over its orifice, to prevent the entrance of foreign bodies.

When this operation is performed for the extraction of foreign bodies in the trachea, a portion of the trachea may either be cut out, or a longitudinal slit should be made in it, which permits of its being again closed immediately after the foreign body is extracted. Certain occurrences are of great moment in the progress of these accidents, which should be carefully attended to by the surgeon: for instance, a child will swallow a bead, a bean, or other substance, which, sliding into the trachea, causes sudden and distressing symptoms as long as the body is forced against the highly sensitive membrane lining the larynx and upper part of the trachea; but if it sinks lower down, where the membrane of the trachea is not so sensitive, all the unpleasant symptoms cease, and the child is suddenly relieved, and is frequently supposed merely to have had a fit, or an attack of the croup. A judicious surgeon will not rest satisfied with these fallacious appearances, but will examine carefully the state of the breathing, with a stetheascope or by other means; when, if a foreign body be present, it will generally be detected, and an operation should be at once performed, to prevent the too frequent occurrence of suffocation, from the body being forced against the rima glottidis, so as to close its aperture. The opening should be made at about the third or fourth cartilaginous ring of the trachea, and not too near to the larynx. If the foreign body is below the opening, it will be forced out in expiration; and if above, it may be seized with a bent forceps. The advantage of making the opening at a little distance from the cricoid cartilage, is to avoid the inflammation which is liable to spread into the more sensitive membrane which lines the

internal surface of the larynx, and the upper portion of the trachea. In certain instances, symptoms are so urgent, that the surgeon has no time to resort to the steps recommended above: in such cases it is advisable as quick as possible to pass a trochar and canula to restore respiration, and then proceed to the steps which may be necessary to remove the foreign body.

The operation for laryngotomy is resorted to when the foreign body or obstruction to respiration, is situated in or above the rima glottidis. Occasionally very smooth or polished bodies may be lodged in the ventricles of the larynx, without producing any immediate urgent symptoms, beyond violent coughing; and will remain impacted in this situation for a considerable time, until eventually abscesses form. Bones of fish, and angular or pointed bodies, on the contrary, get entangled in the rima glottidis, occasioning spasms and other urgent symptoms, quickly followed by suffocation. The patient, unable to speak, generally in these cases points with the finger to the exact point where the body is lodged.

The opening in laryngotomy is most conveniently made in the small triangular space between the thyroid and cricoid cartilages. A small incision, of about an inch in extent, is first made through the common integuments, directly over the part intended to be opened; the incision is then extended between the sterno hyoidei, sterno thyroidei and crico thyroidei muscles, down to the larynx: which being done, a bronchotomy trochar is passed into the larynx, or a portion of the crico thyroidean ligament may be taken out. Care should be taken to prevent the canula from being driven forcibly out by the irritation it occasions at its first introduction: this irritation soon subsides, and the canula may be worn for an indefinite period, unless its presence occasions such a degree of inflammation, that it can no longer be borne.

The most distressing symptoms in the after treatment arises from the continual accumulation of mucus, which is liable to block up the canula: an assistant must therefore attend to remove the mucus with a probe. Sometimes it will be necessary to use a syringe; and advantages has been gained by having two trochars, one to slide into the other, which facilitates the removal of the mucus as often as it may be necessary.

The time that the canula should be worn, and the wound kept open, depends upon the continuance of the obstructed respiration: in general, three weeks or a month, will effect all that may be required; but when protracted beyond that period, the result is generally observed to be unfavorable. There are, however, instances on record, where the canula has been worn for many months. This, as well as every other circumstance attending the after treatment, must depend upon a variety of casualties incident to each individual case. When it is determined to

close the wound, it may be easily effected with strips of adhesive plaister to draw its edges together. When abscesses form in the neighbourhood of the larynx and trachea, they occasionally cause pressure on those parts, and require to be opened: when very deep, they may be successfully treated by openings near the part, to which the matter will very soon extend and make an exit. When behind the cricoid cartilage an operation is sometimes required: an incision must be made down to the thyroid cartilage, which must be taken as a guide; then proceeding backwards, the abscess may be felt and opened.

In cases of obstructed respiration from pressure, caused by foreign bodies lodged within the œsophagus, it seldom if ever happens, that if the body is lodged below the larynx, that it may not be pushed into the stomach, which should therefore be attempted in every instance before resorting to the operation of bronchotomy. Cases are on record where this has been effected after the operation of bronchotomy had been performed, and there was no reason why it should not have been done in the first instance, and the patient saved from the pain of a formidable operation.

Practical remarks connected with the lungs and viscera contained within the thorax, have already been mentioned when speaking of that cavity.—*Vide Vol. II. p.* 172.

Of the Blood.

The description of the blood might very properly follow that of the heart, and vessels, which are formed for its circulation throughout the body; but as the subject is so intimately connected with the function of respiration, it seems more proper to treat of it here, as it may indeed be considered in some measure as a continuation of the physiology of respiration.

The blood forms an intimate part of all living animals; and probably to its influence, in conjunction with that of the nerves, we may refer the most essential seat of vitality.

The use or function of the blood is as various as the different structures of the human body; in each of which it appears to be destined to a peculiar action. Speaking generally it may be said to be a fluid circulating throughout the body in three states, and in three sets or systems of vessels, which have each peculiar characters.

In the first set, the blood is distributed through arteries to

every part of the body, in appropriate quantities necessary to the function of each: these arteries may be termed the vessels of distribution.

In the second set, the blood enters a series of infinitely minute capillary vessels; in which, being acted upon, by the vital influence of the nerves, it is appropriated in the growth, secretion, or excretion of each individual organ: these may therefore be named vessels of appropriation.

The third class or set of vessels are called the veins: these return what remains of the blood, after it has been distributed and partly appropriated, from every part of the body, in order to be again subjected to the process of respiration, and to be replenished by receiving the product of assimilation: these may be termed the vessels of renovation.

In a physiological point of view, the uses of the blood may be therefore comprehended under the three terms of distribution, appropriation, and renovation: functions by which every part of the body is formed, maintained, and renovated.

The blood differs in its properties in the arteries and in the veins, and probably a still greater difference exists in their connecting or capillary systems. [For the general differences between arterial and venous blood, *vide* p. 220.] It is not only the physical properties marking the distinction between venous and arterial blood which render the differences of the two fluids important. In a physiological and pathological point of view, it should be borne in mind, that the red arterial blood is circulating, fitted and destined for all the offices of life; while the modena red or venous blood is flowing towards the heart and lungs, to be renovated for future circulation: hence it is that the loss of venous is not productive of the same injury as that of arterial blood, and the surgeon has not therefore the same dread of fatal consequences: and moreover it should be remembered, that under particular circumstances, even whilst contained in the arteries, the blood may undergo a change of color and qualities, so as to put on all the appearances of venous blood: thus

any cause which greatly retards its flow, may produce such an effect: and hence it is, that in operations for such diseases as diminish or interrupt the natural course of the blood, the surgeon will be induced most carefully to secure all bleeding vessels, although the blood may flow as continuously as if from a vein.

We have hitherto spoken of the blood as a part of the living system; but as it possesses properties very different when separated from the circulation, it will now be necessary to examine the changes which it undergoes out of the body more particularly: and first let us consider it as a homogeneous fluid, or rather as it so appears when flowing from the living body.

The *quantity* of blood, compared to the solids of the body, has been estimated by Sir Astley Cooper at an ounce to a pound: this was the result of many experiments made upon dogs; and, as these are almost the only recorded researches upon this subject, we are perhaps justified in drawing our conclusions from them; but, at the same time, are not to take it for granted that the same proportions exist between the blood and solids of the human species.

The temperature of the blood in a healthy state when flowing from a vein, is estimated to be from 98 to 100° of Farenheit's thermometer; which is much more than the mean degree of the atmospheric heat, though less than the greatest. It is supposed by some, while it is denied by others, that the blood in the living body undergoes a change of temperature, from the influence of the atmosphere; but I believe the difference of opinion originates from one party examining the heat of the body, supposing its temperature to depend entirely upon the blood, while the other examined the heat of the blood itself. It seems, however, now to be generally considered, that the blood is incapable of undergoing any change of temperature while circulating through a living animal: this may be proved by the following experiment:—If you immerse a thermometer in blood flowing from a vein, the heat of that blood will be the same, whether the person has

been exposed to the influence of a high or low temperature: but, on the other hand, if a thermometer be placed in the mouth or anus of a person exposed to a great degree of cold, it has been found not to rise above 76° of Farenheit's thermometer: shewing that the heat of the body depends upon other circumstances than that of the blood.

It has also been maintained, that the heat of the blood varies in different parts of the body; and that the arterial, is two degrees hotter than the venous. Sir Astley Cooper has however, in my opinion, by experiment proved the fallacy of this supposition: he passed a thermometer, made for the purpose, into the jugular vein and carotid artery of a sheep, when they both immediately rose to 104°; remaining, however only at that high temperature as long as the animal was agitated by pain, on the cessation of which they both fell to 102°: proving that in this animal at any rate the arterial and venous blood are of the same temperature; and perhaps proving also, that something between 98°, the computed temperature of the blood when flowing from the living body, and 102° when within it, would be the proper estimate of the blood's heat:—and further, this experiment shews how much the sensible heat of the blood depends upon nervous influence.

The *specific gravity* of blood, as compared to water, varies considerably, but is estimated at 1045, varying to 1054, water being 1000: but in treating of this subject, experimentalists have not mentioned whether they were speaking of arterial or venous blood; for Dr. Davy has shewn, that there is a difference in their specific weight: the former being 1049, and the latter 1051.

It is remarked by physiologists, that the higher the degree of vitality of the animal, the greater the specific gravity of the blood; and this seems to hold good throughout the animal kingdom.

Such are the views which may be taken of the blood under the consideration of it as a homogeneous fluid; in which state it remains, only while circulating in the body;

for soon after its removal from the circulating system, it separates into a solid and a fluid portion: constituting what is termed the coagulation of the blood.

This spontaneous separation leads at once, therefore, to the further consideration of these two parts: of the fluid, which is termed the *serum;* and of the solid mass, which is named the *crassamentum.*

The proportions which these parts bear to each other in the blood of a healthy person, is estimated at about 3-4ths fluid or serum, to 1-4th solid or crassamentum; but there is a considerable variation in these proportions, depending upon the health and vigour of the person from whom the blood is drawn.

The blood begins to coagulate in about four minutes after it has been abstracted; and in about eight, it would appear as if coagulation were complete: this, however, will be found not to be the case; for if the supernatant serum be poured off the coagulum, a further separation will occur, and serum continue to ooze from the crassamentum for ten or twelve hours.

On Coagulation.

This spontaneous separation of the blood when abstracted from its vessels, takes place equally in the air or in a vacuum, during heat or cold, when at rest or in motion, and even where the blood becomes extravasated in the living textures of the body. From the insufficiency of each of these physical conditions to explain the phenomenon of coagulation, John Hunter, and, since his time, other physiologists, have been induced to attribute this change to the loss of the vitality of the blood.

The cause of coagulation by some has been attributed to the change of *temperature* when drawn from the living body: but in answer to this, it has been found to coagulate when extravasated in the living textures, and consequently undergoing no change of temperature. Mr. Hunter found that the exposure of blood, immediately upon being drawn,

to a temperature which caused it to freeze, did not, on its being thawed, prevent its coagulation.

The heat of 120° quickens the coagulation: and it is even probable, if the temperature of the living body could be raised to that degree, that the blood would be coagulated. *Admission of air*, from some experiments of Hewson, appeared to quicken the blood's coagulation in some degree; but it cannot, nevertheless, be supposed to depend upon such admission, as the blood coagulates, as has been before mentioned, when extravasated in the living body.

It has been thought that *motion* might prevent coagulation, and that rest might therefore be assigned as the cause producing it: but by some experiments made by Sir Astley Cooper, it is proved that rest at any rate is not to be considered as the principal cause. He placed two ligatures on the jugular vein of an animal, so as to insulate a portion of blood from the circulation; and under these circumstances the blood did not coagulate for three hours: but on a similar portion of vein being detached from the surrounding cellular membrane, so as to cut off its source of nourishment, and thus destroy its vitality, coagulation took place in ten minutes. From this experiment, Sir Astley Cooper infers that the vessel itself imparts an influence to the blood, which maintains its fluid state.

This supposition is further strengthened by the fact, that in mere dilitation of an artery, before the internal coat has given way, the blood in the dilated part of the vessel does not coagulate; but immediately that the inner coat gives way, a coagulum is formed.

These circumstances may all be considered as tending to prevent coagulation of the blood within the body; but few physiologists have yet directed their attention to the inherent tendency of the blood to coagulate, or the causes which promote its coagulation.

Sir Astley Cooper used however, in his lectures at Guy's Hospital, to ask, as a physiological query, if the property of coagulation in the blood, might not be derived from the

function of digestion. "The gastric juice," said he, "causes the coagulation of milk, and all other nutritious fluids, previous to their assimilation; and in this state they are presented to the absorbent vessels of the villi of the intestines, and conveyed to the blood; imparting, probably, to it, the principle of coagulation." And he used further, in strength of this hypothesis, to remark: that in impaired constitutions, in which the powers of assimilation were weakened, the coagulation, both of the nutritious parts of the food, and of the blood, was similarly interfered with.

Of the Serum.

The serum, as has been before mentioned, bears a proportion, in healthy blood, of 3-4ths to 1-4th of crassamentum: it seems to be the solvent of all the other parts. It is of a yellowish-green or straw color, semitransparent, and fluid in the common temperature of the atmosphere; but at the temperature of 160° of F. it becomes solid, excepting a small portion which still remains fluid, and is termed the *serosity*. The mineral acids and alcohol will also produce coagulation of the serum: the former by its affinity for the salts, and the latter for the water contained within the serum. Other substances will also coagulate it, and none more readily than the acetate of lead.

The specific gravity of the serum is 1.030. It reddens turmeric, and changes the blue of violets to green—a power derived from its alkaline properties.

When coagulated by heat, or any other cause, it forms a firm yellowish-green mass, resembling both in appearance and properties, the white of an egg, but differs from it in being combined with water, and not being contained in a membrane; but as the principle of coagulation is owing to the same substance in each, it has been called *albumen*.

The *albumen* forms about 1-10th of the weight of the serum; has no power of spontaneous coagulation in consequence, as it is supposed, of the presence of alkaline substances, which, if added to blood when first drawn, will pre-

vent its coagulating. When coagulation of the albumen is produced either by heat or acids, the whole will not be converted into a solid mass, as a small quantity of soda in solution will ooze from the coagulum, which is termed the *serosity*; which contains the alkaline substance in so concentrated a form as to resist the action of heat and chemical agents, and in time it is found to re-dissolve a part of the coagulum. When the serum is first separated from the blood, it will be sometimes found, clouded by white globules floating in it: this is most likely to occur if the blood be drawn a short time after a meal, and seems to arise from the chyle not being yet completely mixed with it. It is not however invariably seen, although a person may be bled two or three hours after eating; but it seems to depend upon some diseased condition. Dr. Crawford, formerly one of the physicians of St. Thomas's Hospital, observed this appearance in the blood of a patient of his, labouring under a pulmonary complaint: and Dr. Currie, of Liverpool, saw the same appearance in the serum taken from a person who was supposed to be the subject of inflammation of the spleen.

Mr. Brand has given the following analysis of the human serum :—100 parts containing—

Water	90
Albumen	8
Carbonate of soda . .	1
Muriate of soda . . .	1
	100

Analysis according to Dr. Marcet :—

Water	900.00
Albumen	86.80
Muriates of potash and soda . .	6.60
Muco extractive matter	4.00
Subcarbonate of soda	1.65
Sulphate of potash	0.35
Earthy phosphates	0.60
	1000.00

Some have supposed that there is also a small quantity of sulphur in the serum, and have considered it as a demonstration of the fact, that if serum be heated, and silver put into it, it becomes immediately stained.

One of the demonstrable uses of serum seems to be, for its circulation through the vessels of the transparent parts of the body: as the cornea, in which situation, if the red particles were admitted, vision would be destroyed, or at least impaired.

Of the Crassamentum.

This clot of blood is separable into two portions,—the *fibrin,* constituting 36 parts, and the *red particles* 64 out of 100; the former is that which gives the peculiar and principal properties to the blood; and to the latter is attributed the color of the fluid.

The *fibrin* may be perhaps considered as the most important part of the blood; it is found in all animals, even in those in whose blood no red particles can be detected; it forms the solid structures of the body; and is, in fact, the main constituent of the muscular system. Its specific gravity is somewhat less than that of the serum, hence it floats; but the difference is so inconsiderable it might almost be said to be in an equilibrium. It is obtained by washing the crassamentum, and then separating it from the red particles, when it appears as a tough, white, fibrous, and somewhat elastic body. From the interlacements of its fibres it has been regarded, by some physiologists, as possessing an organized nature; but the arrangement of its parts are neither sufficiently regular nor defined to admit of this supposition. The fibrin separates from the serum spontaneously; but the question is not yet settled, whether its coagulation depends upon something lost or something acquired; the probability lies, as I have before remarked, with the former, but the proofs are only negative.

The grand distinction between the fibrin and albumen is, the alkaline nature of the latter, which forms the great barrier to its self-coagulation; a condition which we might

premise as necessary to a body whose action was destined to be that of a solvent or menstruum.

The red particles become entangled in the crassamentum, simply owing to the common principle of attraction: for all bodies which have a tendency to become solid have a power of separating extraneous bodies from a fluid; it is from this principle that sugar is clarified by blood, and coffee by the white of egg.

Whenever the coagulation of the blood is imperfect, and takes place but slowly, the red particles sink to the bottom of the coagulum, and then the fibrin remains above uncolored by them, and forms what is termed the buffy coat.

Fibrin is not like serum, a compound mass, it is a purely animal proximate principle, or, in other words, a substance which can only be resolved into its elementary constituents.

Fibrin is observed to be more abundant in carnivorous, and albumen in herbivorous animals.

The physical and chemical differences of these two substances, independent of external qualities, are—

1st.—*Fibrin* is spontaneously coagulable—*albumen* is not.

2nd.—*Fibrin* is neither miscible nor soluble in water, whether hot or cold—*albumen* is insoluble in the former, but miscible in the latter.

3rd.—*Fibrin* is acted upon by nitric acid, producing that peculiar substance termed adipocere—*albumen* is converted into gelatine by the same acid.

Their elementary constituents are as follow:—

		Carbon.	*Nitrogen.*	*Oxygen.*	*Hydrogen.*
100 pts.	Fibrin	53	19	19	7
	Albumen	52	15	23	7

Thus it will be seen that these bodies which are so physically different, approach very near to each other in elementary composition. Fibrin contains more nitrogen than albumen, but the latter contains more oxygen than the former.

It is this spontaneous coagulable part of the blood, the fibrin, which is not only of such importance in forming the

solids of the body, but also in repairing wounds, or preventing death from hæmorrhage, which would otherwise unavoidably terminate fatally upon the opening of the smallest blood-vessel; and in forming a barrier to the passage of matter and foreign bodies into the interior of the most important cavities of the body.

The *red particles*, which have already been described as forming 64 parts of a 100 of crassamentum of the human blood, are not found in the blood of all animals, nor indeed in every part of the body of the same animal: hence it may be presumed, that they do not form so important a part of the blood as the other constituents. They are with great difficulty procured free from other substances. Vauquelin recommends the digestion of the crassamentum drained of serum, in dilute sulphuric acid, at a temperature of 160°; the liquid is to be filtered while hot; to be evaporated to half its bulk, and saturated with ammonia; and the coloring matter which falls, washed and dried. Much speculation has existed as to their figure, bulk, &c., as may be supposed must necessarily be the case, when they are estimated to be only 1-4500th of an inch in diamater. Dr. Young describes them as being circular, flattened, transparent disks, with a dark spot in their centre: others consider them spherical, and only appear flattened from the same reason that a small globule seen under an intense magnifying power, will give rise to a similar illusion; or, as a large globe seen by the naked eye at a vast distance. These particles are said to consist of a nucleus and an envelope, in which resides the coloring matter. They are more numerous in arterial than venous blood, and are more abundant in animals in proportion as the ordinary temperature of their body is elevated. When calcined, and digested in muriatic acid, they yield very evident traces of iron: it was formerly supposed this iron was the product of calcination; but it is stated by Prevost and Dumas, that, by the usual tests, the metal may be detected in the pure blood, after a stream of chlorine gas has been passed through it.

It has been stated that the iron forms by weight 1-1000th part of the whole crassamentum; and the total quantity of the metal contained in the blood of an ordinary sized individual, is estimated at about three ounces; but whence the iron proceeds, is beyond the science of philosophy to detect.

The coloring matter, according to Brand, when incinerated, affords a residue consisting of—

Oxide of iron	50.0
Subphosphate of iron	7.5
Phosphate of lime with magnesia	6.0
Lime	20.0
Carbonic acid and loss	16.5
	100.0

It is the iron of the blood which is supposed by Berzelius, to give to it its red color.

The blood is said not unfrequently to contain carbonic acid, which is given off when the blood is greatly heated, or if placed under the receiver of an air pump.

Having detailed the general aspect and properties of the blood immediately upon being withdrawn from the body, it will be very necessary to remark, that there are many circumstances which influence the condition of that fluid whilst circulating in its proper vessels. I have had occasion to notice the general estimate as to the relative properties of the serum and the crassamentum: not only, however, do the properties of these vary in different individuals, but in the same individuals at different times, according to the particular state of constitution, or according as it shall be under the influence of disease.

In the first place, individuals are accasionally observed to labour under what is called fulness of blood, or plethora,—the *hyperæmia* of the French,—a condition which seems to consist of the presence of rather more blood than is necessary for the healthy purposes of the system; while on the

other hand it occasionally happens, that from some cause or other, there is a marked deficiency of that fluid, or rather a marked deficiency of some of its most important constituents, producing what is called inanition,—the *anæmia* of the French.

These respective states of the system, and the influence they exert in the production, modification, and treatment of disease, will of course be fully considered by the medical professor, and cannot properly be treated in detail here, however important it may be, as it must ever be to him who is engaged in any department of the healing art; I must, therefore, content myself with observing, that in certain forms of inanition, and especially that produced by sudden loss of blood, physiology has suggested, and experience has confirmed, that advantage may be derived and even life itself preserved, by mechanically supplying an individual so situated with a quantity of blood taken from another person. This valuable fact has been proved, and more than once practically illustrated by my colleague, Dr. Blundell; but I confess that we are probably yet unacquainted with the least objectionable mode of performing this *transfusion*, as it is called; neither do I consider it satisfactorily established what precise quantity can be injected, in any individual case, with propriety and safety.

With respect to the more intimate changes which the blood, from various causes, sustains whilst circulating through the body, it is a subject replete with the most intense interest; but is one, nevertheless, which in the present state of our knowledge is involved in the greatest mystery. In ancient times disease was almost universally ascribed to a morbid condition of the fluids of the body generally, and of the blood in particular; and it is not improbable that the moderns have run into an opposite extreme: for that the blood must exercise a most important influence upon every part through which it circulates cannot be disputed; yet it is difficult to conceive how this fluid should become diseased independently of a previously dis-

eased condition of those living solids concerned in digestion and assimilation. But whether primary or secondary, we know, as a matter of fact, that the blood does, from various causes, undergo changes while circulating in its vessels; and we have no reason to doubt, when so changed, that it exerts a powerful influence in modifying and aggravating disease.

A common deviation observed is one, the precise nature of which is little known; and it is indicated by the tardy manner in which the blood coagulates on being withdrawn from the body; in consequence of which tardy coagulation, the red particles quit the fibrin, sink to the bottom of the vessel, and thus give rise to that appearance termed "buffy coat," being nothing more than the fibrin divested of red particles. This state, although generally considered as indicating the presence of inflammatory action, and, consequently, the propriety of abstracting blood from the body, yet is an appearance by no means uniformly to be relied upon in either of these respects. John Hunter, it is well known, was led to a belief in the actual vitality of the blood; and although it may be difficult to accede to such a proposition, yet it will be found, on taking a general survey of the morbid changes which take place in the blood during life, that they all appear to be more or less, if not entirely referable to modifications in the energy of the vital powers, either as connected with original constitutions, or as produced by obvious and serious forms of disease. Thus in a person enjoying health and vigor, the blood, when drawn, usually coagulates speedily, and furnishes a firm crassamentum; but when from any cause the vital powers of the system are powerfully, and especially if suddenly weakened, the blood by no means necessarily undergoes a similar change, but either fails to coagulate altogether or does so in a very imperfect manner; whilst its color is by the same causes almost equally modified. We see this fact exemplified in many instances where the nervous system has received a sudden and powerful shock, as from a flash of lightning; or in cases of death

produced by narcotic poisons; in typhus fever too, where the vital powers are greatly sunk, the blood, when drawn, has been found scarcely to coagulate at all, but has presented a dark dingy grumous mass; the little serum that was pressed out, still retaining a few red particles, so as to resemble the washings of flesh. But as to the blood, while circulating in the body, ever becoming actually putrid, there is reason to believe the opinion is erroneous, and has arisen from the rapid changes which the secretions, under such circumstances, undergo. In chronic diseases too we not unfrequently have opportunities of observing remarkable changes to take place in the blood; we observe it in diabetes, and especially in scurvy, in which, as in typhus fever, there exists a singular disposition in the blood to escape from its vessels, giving rise to petechiæ, and vibices or stains, resembling those produced by a bruise. It is right to confess, however, that how far in these instances the condition of the blood is primary, and how far secondary, is a question by no means yet satisfactorily established, although I am disposed to place myself in the ranks of the advocates of the latter.

All that need be added upon this subject is, that recent experiments have shewn the powerful manner in which various agents execute their influence upon the body when injected into the blood-vessels; an influence too, not materially differing from that produced by the same agents when taken into the stomach. Upon this fact it has been proposed to found a novel but energetic mode of administering medicines, when it is desirable to produce a speedy effect, as for example:—a minute quantity of tartar emetic injected into the veins will quickly induce vomiting, and may, therefore, be administered in this way when, from stubbornness or insensibility, the person who has swallowed poison cannot be made to take an ordinary emetic, or merely for the sake of its more immediate operation.

After having treated of the blood, the fluid destined to be circulated throughout the body, we have next to describe the heart, arteries, and veins,—the organs by which the

circulation is performed,—and the absorbents, as accessory to this function.

Of the Heart and Pericardium.

On opening the cavity of the thorax the heart does not present itself to view, being enclosed in its proper splanchnic membrane the pericardium.

The pericardium covers the heart precisely in the same manner, as the other serous splanchnic membranes of the thorax and abdomen enclose their respective viscera. It first forms a close covering to the whole exterior surface of the heart, together with the commencement of the large vessels which go out of, and the termination of those which enter into it: from these vessels it is reflected, forming a bag, in which the heart, with its closely investing membrane, is suspended. This position of the heart has not been unaptly compared to the situation of the head of a person enclosed in a double night-cap. The form and size of the pericardium corresponds to that of the heart: it is situated obliquely between the pleuræ; and is bounded in *front,* by the thymus gland, triangularis sterni muscle, and the sternum; *behind,* by the posterior mediastinum and its contents; *laterally,* by the pleuræ, excepting where it is in some measure separated from them by the phrenic nerves; and *inferiorly,* it rests upon the diaphragm.

The pericardium is constructed similarly to the other serous membranes, but is somewhat thicker in its texture, which has led to its division into two layers: an external fibrous, and an internal serous. The external fibrous membrane is in contact with the heart, vessels, pleuræ and diaphragm, and presents an irregular surface, in consequence of the prolongations or attachments which insensibly lose themselves upon the eight blood-vessels which they encircle: the inferior cava having no fibrous sheath, in consequence of its entrance into the auricle through the centre of the diaphragm. This membrane resembles the dura mater in its pearly aponeurotic color: its fibres pass in bundles or sepa-

rated fasciculi, which intersect each other, and are most visible in the direction of the long axis of the cone. The inner or serous layer lines the external fibrous throughout its whole course, being most easily separated from it where it is reflected from the vessels. It presents an internal, smooth, lubricated surface, forming a closed cavity, into which a serous fluid or halitus is secreted, to facilitate the motions of the heart.

The *arteries* which supply this membrane are derived from various sources: as the phrenic, bronchial, œsophageal, coronary, internal mammary, and not unfrequently from the aorta itself.

The *veins* correspond to the course of the arteries, and principally terminate in the vena azygos.

The *absorbents* pass into glands which are placed at the root of the cava, and origin of the aorta: one large gland is usually found in the situation of the ductus arteriosus.

The *nerves* are with great difficulty traced to the pericardium: they are minute filaments, derived from the cardiac branches of the sympathetic and pneumo gastric nerves.

The *use* of the pericardium is not only for the purpose of facilitating the motions of the heart, but to maintain its proper position under the various situations or attitudes of the body.

The liquor pericardii or fluid secreted by the pericardium, according to the analysis of Dr. Bostock, contains—

Water	92.0
Albumen	5.5
Mucus	2.0
Muriate of soda . .	0.5
	100.0

This fluid is liable to dropsical accumulations, either from an increased action in the arteries, or a diminished action in the absorbents, similar to the secretion of the other serous membranes. The distention thus produced leads to difficult

respiration; and in particular positions of the body, forms an impediment to the circulation of the blood. The reflected portion of the pericardium will sometimes become adherent to the cardiac or close portion by adhesive inflammation. This circumstance also leads to impeded circulation and respiration, under every exertion of the body which tends to a quickened action of the heart.

The Heart.

The heart is a conical, hollow, muscular organ, placed obliquely between the pleuræ; its base being situated superiorly and posteriorly, while its apex inclines forwards, downwards and outwards towards the sternal end of the sixth rib on the left side of the cavity of the thorax. The heart is retained in this situation by its pericardium and great vessels, supported by the diaphragm: it is, however, subject to a slight deviation in its position from the motions of the diaphragm and other parts concerned in the function of respiration, as well as the positions of the body in the erect or recumbent postures.

The figure of the heart is irregularly conical; having an anterior surface more convex than its posterior, and a left edge more rounded than its right: besides which it has an apex and a base.

Its *anterior convex surface* presents in its middle a groove, which divides it unequally into two portions, the larger of which is on the right side. In this groove the coronary artery and vein pass, obliquely from above downwards, and from left to right.

The *posterior surface* is nearly horizontal, resting on the centre of the diaphragm. The posterior coronary artery and vein traverses it in a groove nearly vertically, and unites with the anterior coronary vessels at the apex of the heart. The portion of this surface on the left of the groove is larger than that on the right.

The *left edge* of the heart, thick, obtuse, and rounded, is directed backwards and upwards; while the *right side* is

thinner and longer than the left, and rests upon the diaphragm.

The *base* of the heart is placed superiorly and posteriorly opposite to the fourth dorsal vertebra: is slightly inclined from above downwards, and from left to right. It is separated from the vertebral column by the contents of the posterior mediastinum. On the base of the heart, an oblique groove marks the separation of the auricles and ventricles.

The *apex* of the heart passes obliquely to the left into a notch of the left lung, which corresponds to the separation of the lobes, and is marked by a groove or notch, formed by the union of the grooves of the anterior and posterior surfaces. It is the apex of the heart which is felt to pulsate at the interval of the cartilages of the fifth and sixth ribs.

The interior of the heart is divided into four distinct cavities, named the two auricles and the two ventricles. The two auricles occupy the base of the heart, and the two ventricles the body and apex of the organ.

The auricles on each side of the heart communicate with their corresponding ventricles but not with each other, excepting only the two auricles, which, in the fœtal state, have an opening, the use of which is connected with the peculiar circulation of the fœtus in embryo, hereafter to be more particularly described.

The right auricle and ventricle are distinguished from those of the left side by the character of the blood they respectively contain, and by the separate directions in which they are destined to propel it.

In the right there is found venous blood, of a dark modena red color, which is destined to be circulated through the lungs for its decarbonization: this side has therefore been termed the pulmonary or venous heart. In the left side the blood is of a florid red color, having undergone the action of the lungs, and being thus fitted for its transmission to every part of the body, by the action of the left ventricle; hence the left auricle and ventricle has been termed the arterial or systematic heart.

The circumstances which we have already described are observable while the heart is yet in situ; but to observe the more minute particulars of its structure the organ may now be removed from the thorax, together with so much of the large vessels as is necessary to demonstrate their particular connections.

Of the Right or Pulmonary Heart.

First, of the right auricle: it is situated at the inferior, anterior and right side of the base of the heart, and rests on the diaphragm; it is of an irregular figure, and has derived its name of auricle from an imperfect resemblance to the ears of quadrupeds. It has a long axis, placed transversely, terminating anteriorly, between the right ventricle and the aorta, in a lappet or apex, which is named the proper auricle. In order to examine the interior of the auricle, its cavity should be opened in the following manner:—a pair of scissors should be introduced into the superior cava, in order to slit open its anterior wall, extending the opening across the auricle itself, and through the truncated inferior cava; from the centre of this opening a second should be made, at right angles with the first, extending from the middle of the auricle, along its long axis, to the termination of its lappet or apex, which will expose the whole of the interior of the auricle.

The parts first presenting themselves to view, are the posterior larger portion, smooth, and as it were a continuation of the vein, and its anterior part irregular, marked by the deep rugæ or muscular columns of the true auricle: the first is named the sinus venosus, the second the true or proper auricle, or auricular appendix.

The direction of the two venæ cavæ should now be observed. The superior cava is directed forwards towards the opening from the auricle to the right ventricle: the inferior cava is directed upwards and to the left, towards the left side of the auricle, in which situation the foramen ovale of the fœtus is placed. Hence it has been inferred, that the supe-

rior cava sends all its blood to the right ventricle in the fœtal state; while the inferior cava, transmits its blood directly through the auricular partition to the left auricle. On the posterior surface of the auricle there are also to be observed, first, at the opening of the superior cava, a tubercle or prominence, directed obliquely upwards and inwards, which is termed the *tuberculum Loweri.* This prominence, although generally found in the lower animals, is sometimes scarcely perceptible in the human heart. The use attributed to this prominence is, to direct the blood of the superior cava into the right ventricle.

The orifice of the inferior cava is furnished with a membranous fold of a semilunar form, termed the *eustachian valve.* Its inferior cornu commences from the anterior surface of the inferior cava; while its superior cornu passes upwards, so as to form the anterior part of the circumference of the fossa ovalis. Its convexity is attached; while its concavity is free, and floating in such a manner as to have led to the belief, that this valve is formed for the purpose of directing all the blood of the inferior cava through the foramen ovale of the fœtus. This valve being found much more developed in the fœtal than the adult state, is supposed to corroborate the above opinion.

Above, the eustachian valve, upon the left side of the right auricle, in that portion which forms the partition between the two auricles, is a depression termed the *fossa ovalis;* which is more distinct above than below, and appears a continuation of the vena cava. The surface of this depression is not always smooth: it presents a thick inferior extremity, which is bounded by the eustachian valve. It is not an imperforate partition; but the opening is so directed, that, after birth, no blood can pass from the right to the left auricle, although the handle of a scalpel, directed from behind forwards, may be directed from one cavity to the other.

Below, the eustachian valve, between it and the opening into the right ventricle, is placed the opening common to the *coronary veins;* which is furnished by a small fold of the

inner membrane of the auricle, termed the *semilunar valve.* Its free edge is directed downwards, and is for the purpose of preventing the regurgitation of the blood into the vein.

Anteriorly, the right auricle is furnished with two openings: a smaller one above, leading into the true appendix, which seems to be made up of a number of muscular fibres interlacing each other, forming the true contractile portion of the auricle. The larger opening, which is below, leads into the right ventricle, and is termed the right *auriculo-ventricular opening.* The circumference of this aperture is elliptical in an empty heart, but may be supposed to be circular when the heart is full: it forms the line of demarkation between the auricle and the ventricle, and is marked by a white line, which is termed the *zona tendinea.* There is nothing more remarkable in the right auricle, unless we mention numerous small openings, not furnished with valves, termed the *foramina thebesii.* They have been believed, by some anatomists, to be the terminations of small veins.

The right auricle, therefore, is furnished with four openings: the two cavæ, opening to the coronary vein; and the auriculo-ventricular opening.

The *right ventricle*—comprises the anterior portion of the heart: it is of a triangular figure, the base being directed backwards and upwards towards the right auricle, with which it is connected; while the apex is directed downwards, but not sufficiently forwards as to form the true apex of the organ. The anterior parietes or wall of the right ventricle, forms the anterior convex surface of the heart: its posterior wall is the partition common to it and the left ventricle, termed the *septum cordis.*

To examine the interior of the right ventricle a section should be made along its acute edge, from the base to the apex, and a second incision along the septum cordis, so as to form a triangular flap of the anterior wall of the ventricle attached to its base. On raising this flap, the form of the cavity of the ventricle will be found to correspond to the

exterior wall; being larger where it is attached to the auricle, and smaller at its apex.

The parts to be observed in the right ventricle are, first, the irregular surface produced by the muscular fibres passing in various directions. These muscular fibres are divided into two sets: the one set, belonging entirely to the walls of the ventricle, termed the *musculi pectinati*, are destined to propel the blood from the ventricle; being, by their peculiar arrangement and attachments, capable of contracting the capacity of the cavity. The second set, termed *carneæ columnæ*, are somewhat pyramidal in their form, having their bases attached to the sides of the ventricle, while their apices are free and floating within its cavity, being attached only to small tendinous cords belonging to the valvular apparatus of the right auriculo-ventricular opening: by which attachment the adaptation of this apparatus is regulated. At the base of the right ventricle two openings may be observed: the larger posterior one being the *auriculo-ventricular aperture;* and the smaller anterior one, the *opening to the pulmonary artery.* The former is elliptical, and the latter rounded in its form, and are both of them furnished with valves.

The valve of the auriculo-ventricular opening is furnished with three processes or flaps, termed therefore the *tricuspid valve.* It commences in a broad tendinous curtain, termed the *cortina tendinea* from the zona tendinea, which has already been mentioned as the line of demarkation between the auricle and ventricle. This broad curtain is disposed in three flaps, from the inferior extremities of which, little tendinous cords, called the *chordæ tendineæ,* are given off, which are attached to the apices of the carneæ columnæ. These parts entering into the formation of the tricuspid valve, are so arranged that one flap or division is placed anteriorly, a second posteriorly connected with the septum cordis, while the third and largest is to the left, separating the auriculo-ventricular opening from the opening of the pulmonary artery.

It may here be observed, that the upper part of the

anterior wall of the ventricle is smooth; and, in conjunction with the third or largest portion of the tricuspid valve, facilitates the direction of the flow of blood directly to the opening of the pulmonary artery.

The opening of the pulmonary artery is small and rounded, and is situated at the highest point of the left extremity of the ventricle. The internal coat of the pulmonary artery is a continuation of the internal lining membrane of the heart; but its middle fibrous coat is connected to the fleshy fibres of the ventricle by three distinct convex arrangements of fibres, marked internally by a white line, from which three *semilunar valves* extend into the artery, forming a complete barrier to any regurgitation of blood from the artery into the ventricle. Each similunar valve is convex and fixed towards the heart, and free and floating within the calibre of the artery, throughout the course of their straight edges. In the centre of each floating edge is a small thickened body, termed the *corpusculum arantii*: the uses of which are said to be for the purpose of filling up the small triangular space, which would otherwise necessarily result from the approximation of the three convex surfaces of the valve.

The pulmonary artery is distributed to the lungs, and completes the circulation of the pulmonary side of the heart. The pulmonary veins arise from the parenchyma of the lungs, as has been before described, and convey the blood by four large trunks to the left or systematic side of the heart.

The Left or Systematic Heart.

The *left auricle* is situated at the superior, posterior, and left part of the base of the heart. In situ it can hardly be perceived, being hidden by the large vessels of the heart; its apex only rising sufficiently forward to the left of the pulmonary artery as to be brought into view. Its form is rather more square than that of the right, and its capacity is about one fifth less. To expose its interior, the four pulmonary veins should be cut open, and the sections continued to the

centre of the auricle in the form of a cross. This cavity, like that of the right, contains four surfaces: on the *posterior* surface there is nothing particular to observe, excepting that it receives the right pulmonary veins at its upper part.

The *anterior* surface forms a part of two apertures: one below, the largest, leads into the left ventricle; and above, a smaller one leads to the cavity of the true auricle or appendix; and is marked like that on the right side, by muscular bands, but not so distinct.

The *right* surface forms the portion of the septum between the two auricles: upon it is to be observed the remains of the foramen ovale, less distinct, however, than in the right auricle: it is best seen by holding the septum up to the light; when, from its thinness, it is rendered perfectly obvious.

The *left* surface admits of the opening of the two corresponding pulmonary veins, which are much nearer to each other than those on the posterior surface.

The auriculo-ventricular opening is marked by a white line similar to that on the right side, termed the zona tendinea.

There are, therefore, five openings to the left auricle: the auriculo-ventricular opening, and the orifices of the four pulmonary veins.

The *left ventricle* occupies the posterior and left side of the heart: it is conical in its form, and its anterior extremity constitutes the true apex of the heart. It is somewhat longer, but narrower, than the right ventricle. Its parieties are much thicker, and seem completely to form the septum cordis. To expose its cavity, a section should be made along the left side of the septum, from the base to its apex. The greater thickness of its parieties, and the size and strength of the carneæ columnæ, form a grand distinguishing mark between the two ventricles. The distribution both of the carneæ columnæ and musculi pectinati, are much the same as those on the right side, excepting that they are infinitely stronger. At the upper part of the cavity there are

two apertures: the larger is placed posteriorly, and is the left *auriculo-ventricular opening;* the smaller is placed anteriorly, is of a triangular form, and is the *opening into the aorta.*

Around the auriculo-ventricular opening, from the zona tendinea, there descends, as on the right side, the cortina tendinea; but which divides itself into two, instead of three flaps: it is termed the *mitral* or *bicuspid valve,* being fixed by the cordæ tendineæ to the free extremities of the carneæ columnæ, and answers the purpose of preventing the regurgitation of the blood from the ventricle. The larger portion of this valve separates the aortic from the auricular opening; and in conjunction with the anterior part of the ventricle, which is smooth, assists in directing the blood into the aorta. The aortic opening is constructed precisely in the same manner as that of the pulmonary artery; its fibrous coat being connected with the muscular parieties of the heart, while its inner coat is continuous with its lining membrane, and forms three distinct *semilunar valves,* furnished with corpuscula arantii, for the purpose of preventing regurgitation from the aorta into the ventricle. The aorta conveys the blood to every part of the body.

Organization of the Heart.

The heart, we have before observed, is a hollow muscle. It is covered externally, by a strong serous tunic, the pericardium, which has already been described; internally, its cavities are lined by membranes, which are continuous with the inner coats of the blood-vessels, and which is closely connected by dense cellular tissue to the muscular fibres of the organ.

The cavities within the heart are so constructed, that its muscular action is in proportion to the force required in propelling the current of the blood to its ultimate destination. Thus the right side of the heart has walls much thinner than the left, having to propel the blood merely through the lungs; while the cavities of the left side of the heart have

walls of great muscular power and thickness, destined to influence the circulation of the blood throughout the whole arterial system of the remaining part of the body.

In the arrangement of the fibres which compose the walls of the cavities of the heart, those of the auricles first claim our attention.

In the right auricle, the muscular fibres form longitudinal bundles, thickest towards the union of the two venæ cavæ, and having in this situation a considerable deposit of adeps between them and the serous lamina of the pericardium. In the proper auricle they pass in isolated fasciculi, between which the walls are semitransparent, similar to the veins. These bundles, from the regularity of their disposition, similar to the teeth of a comb, have been termed the musculi pectinati.

In the left auricle, the muscular fibres are thicker than in the right, and are not so much disposed in parallel bundles, but in fasciculi, which cross each other irregularly, especially those which are deep-seated.

The septum common to the two auricles, is composed of fibres, which are uniform in their direction, and of considerable thickness.

In the right ventricle, the muscular fibres on the external surface appear to take their origin from the auriculo-ventricular opening, and pass obliquely downwards and forwards from the right towards the left ventricle, where they are interlaced with the muscular fibres of the septum: more internally the fibres take an arrangement, somewhat similar to those of the auricles, but stronger, and more numerous; several of which pass off from the internal surface, to form the columnæ carneæ. It is extremely difficult to unravel the muscular fibres of the heart; they are not connected, as in other muscular structures, by cellular membrane, distinguishing their minutest fasciculi; but are minutely interwoven, arising and terminating, more or less, in every part of the organ, yet so as not to be distinctly traced, excepting to the columnæ carneæ.

In the left ventricle, the muscular wall is much stronger and thicker than in the right, its fibres being more apparent on its external surface, passing in a longitudinal direction from its base to the apex. Similar to the right ventricle, its middle muscular fibres take a circular direction, while its internal give off numerous columnæ carneæ; these are most abundant towards the opening of the auricles, but towards the entrance of the artery the ventricle is smooth and even. The left ventricle contributes chiefly to the formation of the septum cordis, bulging so as to present a convex surface within the right ventricle, which may be said to be a fleshy wall wrapped around it. The fibres of the left ventricle take a tortuous course from its base to the apex, and hence are one fourth longer than the distance between these points; the two sets from either ventricle acting in opposite directions, render only one half of the quantity of contraction in each fibre necessary, that would be required had their course been direct; while at the same time it effectually prevents an inconvenient lateral motion.

The motion produced by the muscular action of the ventricles of the heart, tends to draw the apex towards the basis, and their sides toward each other; the septum acting as a side to the left ventricle, while the right ventricle increases the same force by supporting the septum, at the same time it propels its own blood by the contraction of its exterior wall. Hence it is, that the right ventricle terminates on the side of the septum, before the apex of the heart is formed, thus leaving the action of the left ventricle without interference. The muscular fibres of the ventricles are not continuous with the auricles; this may be seen by boiling the heart for three or four hours, when the auricles may be separated from the ventricles, and their distinct arrangement of fibres demonstrated. The arteries arise from the muscular fibres of the ventricles rather abruptly, the fibrous coat of the vessels terminating in festoons, while the serous membrane of the heart connects them externally, and the inner lining of the ventricles internally first forming the semilunar valves.

The heart is supplied with blood from the two *coronary arteries*, while the *veins* correspond to the arteries, and terminate in the right auricle, just below the eustachian valve.

Its *nerves* are very numerous, but small; they are derived from the sympathetic and pneumo gastric.

Its *absorbents* terminate in numerous glands, which are situated between the arch of the aorta and pulmonary artery.

Of the Physiology of the Arteries.

The arteries are elastic tubes, which convey the blood from the heart to every part of the living system.

They are composed of three different tunics or coats, and in certain instances receive a partial covering from neighbouring serous surfaces; as from the pericardium, at their origin, within the bag formed by that membrane around the heart, and from the pleuræ and peritoneum in various situations within the thorax and abdomen.

The *external coat* is elastic, and is composed of fibres resembling cellular membrane, but which are much more dense, and closely interwoven together; and indeed by some anatomists it has been considered to be nothing more than a condensation of the surrounding cellular substance.

The *second coat* is thicker and firmer than the first, and is of a yellowish color; it is called the muscular coat, although it differs materially from real muscle. Its fibres pass in a circular direction around the tube, and like those of the external coat are very elastic, whereas muscle is not. When boiled the arteries are convertible into jelly, but muscular fibre does not undergo this change though boiled for any length of time: the middle or muscular coat is thicker and more contractile in the smaller arteries than in the large, and the external or elastic coat is thickest in the larger arteries.

The *third*, or *inner coat*, is called the membranous; it is thin in comparison to the others, and its internal surface is smooth, polished, and slippery, which offers the least possible resistance to the flow of the blood.

This coat is firm and dense, and appears to prevent transudation, by confining the circulating fluids within the artery: it is also supposed to have a power of maintaining the fluidity of the blood; for any circumstance which destroys its continuity, will produce an immediate coagulation of the blood in the part, as is proved by direct experiment, or the examination of an aneurism in its earliest stage. Its extensibility is not so great as that of the outer coats; hence it is frequently ruptured, causing aneurism. It is this coat which is cut through upon the application of ligatures; and when thus divided, its torn surface hastens the process of adhesion.

In the distribution of the arteries throughout the body, considerable variety occurs, according with the function and other circumstances connected with the economy of individual parts. Upon this account they have been generally divided into two systems, named the sanguineous and the serous. But this division was founded on the supposition, that those vessels which do not convey red particles, convey serum only. More recent observations however prove, that all the elements of the blood may be contained in the transparent vessels; and that even the red particles may exist, though so few in number, and infinitely separated, as to be incapable of reflecting sufficient light to cause the appearance of their red color.

The arterial distribution, generally speaking, is for the various purposes of the growth, nourishment, and peculiar function of each individual part; hence the arteries have various ultimate terminations. They are in general accompanied by corresponding veins, by absorbents, and nerves, and are embedded in a certain quantity of cellular membrane. Five modes of termination are usually enumerated; but from the infinitely minute structures into which the capillary system divides, eluding the highest microscopical powers, it is very possible that we are not acquainted with the real nature of many glandular and other ultimate vascular terminations. Those which are visible are—

First, in *anastomosis,* where one branch uniting with

another, gives off succeeding branches, fed by their united currents: this mode of distribution prevails in the mesentery, and tends to equalize the current distributed to the extensive surface of the intestinal canal.

Secondly, in *veins* which return the blood to the heart.

Thirdly, in *exhalents;* which, throughout the skin, produces the matters of perspiration; and, in the serous cavities, the fluids they respectively exhale.

Fourthly, in *cavernous cells* of erectile tissues, as in the spleen, penis, &c. The veins arising from these cells are supposed to be less numerous, thus causing the phenomenon of erection.

Fifthly, in *glandular structures,* such terminations are, generally speaking, involved in much obscurity, and has occasioned great contrariety of opinion. From the ultimate glandular structures, two orders of vessels may be clearly stated to arise: one the veins, which convey the refluent blood; the other the excretory vessel or duct, which conveys the product of each glandular secretion.

There is yet an extensive mode of arterial termination which is not comprehended in the above enumeration: namely, in the general distribution of the capillary system not directly disposed in glandular and secreting surfaces, but which are for the purpose of depositing the different constituents of the organismus, and which are again removed by the circulation and action of the absorbents.

The fluids in circulation are therefore contained in three distinct orders of vessels: arteries, veins, and absorbents; and the union formed by these systems comprise an apparatus named the capillary system, regulated and modified by the alternate distributions of the nerves and their peculiar influence.

In a physiological point of view, the capillary system is by far the most important part of the circulation, being the seat of all the principal functions, as well as the phenomena of health and disease. As yet we are entirely ignorant of the part which the nerves contribute in the performance of the

various phenomena resulting from the arterial circulation: all that we can demonstrate is, that when the influence of the nerves is cut off by the division of their main trunks, or deranged in the progress of disease, the various phenomena constituting healthy action, are either deranged or altogether changed. Great difficulty also exists in accounting for the circle completed in the course of the fluids throughout the body; and more particularly in that portion of them conveyed through the veins, absorbents, and capillaries.

In the arteries, the blood is first propelled by the powerful muscular contraction of the heart; the force of which has been ascertained to be equal to the pressure of a column of fluid eight feet in height, or of four pounds upon a square inch of their surface.

The quantity of blood thus propelled, according to Blumenbach, at each contraction of the left ventricle, is two ounces; the whole mass of blood, thirty-three pounds; and the number of pulsations, seventy-five in a minute; which is probably as near the truth as any calculation which has been made: hence the whole mass of blood passes the heart in about two minutes and a half, or twenty-four times in an hour. It must however be observed, that the blood circulates with different velocities in different parts of the system.

Many speculations and idle theories have existed respecting the power which first excites the heart's contraction, and continues through life to maintain its constant and regular motions. The stimulus of the blood entering the ventricles, and the contractility of muscular fibre upon the application of stimuli, seem sufficient to account for its action, without recurring to other, or imaginary causes. The continuance of the circulation in the arterial system, has also been a fruitful source of controversy; and opinions have been advocated between the extremes of considering the arteries as mere hydraulic tubes, subject to the action of the heart, and of considering their action to depend entirely in their own vital muscular powers. The motion of the blood in the arteries is shewn to depend in part on a power foreign to the heart, by

the different velocity with which it flows, and the increased force of the pulsation in a part diseased, depending upon the effects of external stimuli, and from a number of internal causes. These facts prove an essential vitality in the artery, and at the same time an alternate state of contraction and dilatation, whether that contraction depends on muscularity in the vessel or not.

It was the opinion of John Hunter that the arteries possessed both an elastic and a proper contractile or muscular power, and that the latter ceased with life, while the former remained as long as the parts retained their structure and composition.

The question resolves itself upon the fact, whether muscularity may or may not exist independent of the peculiar muscular component fibrin, which is not to be detected in the composition of the arteries. Dr. Wilson Philip (*Med. Chir. Trans.* Vol. xii. p. 401.) states that the capillaries may be seen to contract upon the application of those stimuli which produce the contraction of muscular fibre; the same has been observed by Dr. Thompson. Dr. Phillip also observes, that the blood in the capillaries is influenced by stimulants applied to the central parts of the nervous system. (*Expt. Enquiry*, p. 291.—*et seq.*)

I witnessed the following experiment, performed by my friend, Dr. Marshall Hall:—the heart of a frog was removed; then submitting one of its large arteries to a good microscope, it was seen to pulsate for twenty minutes afterwards, which clearly proves that the arteries possess a contractile power for the above period, equivalent to all the purposes of their circulation, independent of the heart.

This pulsating contractile power may be referred to the middle muscular coat, which is supposed to be stronger in the small than in the large arteries; but it is no doubt aided by the elastic external coat.

To the elastic and contractile qualities of the arteries the power of accommodating their volume to the blood contained in them must be attributed. Dr. Hall took seventeen quarts

of blood from a horse before it died, in whose body only three quarts more were found, and yet the moment before death the tension of the arteries sustained a column of two feet of blood in his experimental tube. It was observed by Dr. Parry that the artery of a living animal, exposed by dissection to the air, sometimes contracts suddenly to a great degree, and occasionally a single fibre only will contract, affecting the channel similar to a thread tied around it.

The sudden effects of mental influence upon the arteries of the face and neck, in which they dilate, so as to admit red particles, producing a blush, or contract, so as to drive all the red blood from them during the passion of anger or fear, are too remarkable to leave a doubt of the vital action of the arteries; and in these instances their contraction and dilatation is as ready as the action of proper muscles.

Of the Pulse.

The most remarkable phenomenon connected with the arterial circulation, is the occurrence of the pulse, which is simultaneous, in all the arteries throughout the body, with the muscular contraction or systole of the heart. We have already shewn that the action of the heart is not the sole cause of the pulse. Much is to be attributed to the particular construction and properties of the arteries themselves; as may be seen by the continuation of the action of pulsation when the heart has been removed. Nevertheless, it appears by the instantaneous consent of the pulse with the contraction of the heart, that a certain influence actuates the extreme branches of the arteries at the same time with the heart; and this influence can be compared to nothing but a muscular action, the velocity of which, both in voluntary and involuntary muscles, has something in it much resembling the phenomena of electricity.

A pulse may indeed be produced in a dead body, by filling the arteries with water to the tension of life, and then injecting at intervals as much water as the heart throws off blood at a pulse; but the beats, although the artery is fully

distended, are very dissimilar from the living pulse: and the same result occurs from connecting the artery of a living animal with the vessels of a dead one.

Parry, in his experiments on the pulse, could not observe, even by the aid of a microscope, the slightest dilatation or contraction of the artery during its pulsation.

Various conjectures have therefore been made to account for the sensible pulsation experienced on pressing the finger against an artery; and although generally considered as produced by the mere dilatation of the artery from the forcible jet of blood thrown into it by the heart, the experiment of Dr. Parry, and its synchronous beat with the heart, shew that this cannot be the sole cause. Bichat refers it to a change of position in the artery, produced by the sudden impetus of the heart's action. Parry, however, denies that the change of position can account for the effect produced. It has been asserted, that the arteries at all times exert a degree of contraction upon the blood they contain, so as to accommodate themselves exactly to their contents; and that when the finger is pressed upon an artery, it interferes with its natural contraction, and the sensation experienced by the finger, termed the pulse, is the consequence. This, however, although it may in some measure account for the increased expansion of the vessel, as the blood is forced under the portion pressed, cannot be considered as the only cause of the effect produced; for without any pressure, the pulsation is distinctly visible in the radial arteries at the wrists, and they have a slight lateral movement towards the ulna at each pulsation; while to the sense of touch, it is accompanied with perceptible dilatation.

The rapidity of the pulse has been compared to the passage of sound. Now, undoubtedly, fluids are elastic, and convey sound more rapidly than the air; and the arteries present an uninterrupted channel or column of fluid, from the heart to their extreme branches; and a shock, or momentum imparted by the heart, might be experienced in the smaller vessels almost instantaneously. Thus the scratch

of a pin at one end of a deal rod, is communicated to the ear at the other end of the rod, by the elastic vibration, with a velocity quite equal to any perceptible measurement in the length of the animal circulation. Dr. Arnot has observed, "that an animal's intestine prepared and filled with water, and laid upon a table, or a full vein in a living body, carries a rapid and distinct pulse to a great distance when gently tapped by a finger. The cause of sensation there cannot be the simple forward rush, without tumefaction, described by Dr. Young, and Dr. Parry."

The elasticity of the arteries themselves, may increase the effect of the momentum imparted by the heart; but at the same time, they are disposed in various ways, both to retard or to increase its movements.

Thus the great force with which the blood is first propelled from the heart, is met by the curved form and branches of arteries passing off in acute angles; at a further distance from the heart, they pass off at right angles; while at the greatest distance, obtuse angles prevail. In certain instances, the arteries take a very tortuous course, which both retards the flow of blood, and allows of extensive motion; such, generally, is the distribution of vessels to hollow viscera, and to the lips, &c. In other instances, two currents of blood meet at the anastomosing branch of a vessel, and unite their forces.

From these several causes, there is an evident loss of power in the progress of the circulation from the heart, and which gradually lessens until the flow of the blood in the capillary vessels is in a stream, which is nearly of a uniform current; but which is kept up by the increased vitality and thickness of the muscular coat, and is of such a force as to empty the arteries, and force the blood into the veins, so as to gorge them in the manner in which they are generally found in the dead body.

Some difference occurs in the arterial circulation in the brain, consisting in a provision to prevent the rapid flow of blood. The arteries, as they enter the cranium, pass through

tortuous long canals, which prevent a sudden increase of blood. Having gained the interior of the cranium they become thinner, resembling the veins, and having much less of the muscular coat, so that their sides collapse, and tend to oppose and diminish the force of the current of the blood. Another circumstance must be noticed with regard to the circulation in the brain; which is, the mechanical resistance of the bones of the skull, tending to prevent the formation of a vacuum, and consequently, by this power alone, to maintain an equilibrium of fluid circulation. Thus the arteries cannot fill themselves beyond a due proportion, without causing a corresponding diminution in the volume of the contents of the veins; and *vice versa*. Hence it is, that the muscular action of the arteries and the distribution of the veins, are so peculiar within the cavity of the cranium.

In a pathological point of view, the indications of the pulse in health and disease, are of the utmost importance, both to the surgeon and the physician.

These indications may be considered, first, with regard to the number of pulsations in a given time; producing a frequent, slow, intermittent, regular, or varying pulse. Secondly, with regard to the force of the heart's action; causing a bounding, feeble, full, long, or labouring pulse. Thirdly, in respect to the rigidity or tension in the arterial system; producing a hard, sharp, wiry, weak, soft, or yielding pulse. The size of the artery also influences the pulse, and may occasion it to be full, large, strong, small, or weak. The application of these several states to peculiar diseased actions, and derangements of the system, belongs rather to the history of each of such diseases in particular, and would be far too voluminous for the purposes of the present work.

Of the Capillary Circulation.

Having already noticed that the circulation of the fluids of the human body is carried on by the arteries, veins, and absorbents, I consider it right here separately to consider that portion of the above circulation, which is more particu-

larly destined to perform those chemical and vital changes, constituting all the principal phenomena of life itself.

The first, and not the least interesting portion of the capillary circulation, is that part of it which maintains the life of the blood-vessels themselves.

The minute division of the capillary vessels, forms one of those infinitudes, which the human mind feels itself incapable of comprehending. Some idea of it may be entertained by numerical comparisons; but in the attempt to define a limit, numbers themselves are of no avail.

Thus the *vasa vasorum*, which support the arteries, veins, and absorbents, must themselves have their vessels supporting them; and thus we have no conceivable limit to these vessels: and from hence the speculative hypothesis of Ruysch, who imagined that the whole body is composed of nothing but capillary tubes, has received so many supporters.

The most important consideration attached to these vessels is, that as long as the blood flows under the control of the heart and larger arteries, it fulfils no purpose of nutrition or secretion. These important functions reside in the capillary vessels, modified, however, by nervous influence, which in every organ may be supposed to unite with the capillary vessel, in producing the various secretions and excretions of the glandular and membranous tissues. The capillary vessels cannot be assigned to the artery, more than to the vein; nor can we define the limit where the capillary deposits new bone, muscle, or blood-vessel, &c., any more distinctly than the origin of those absorbent vessels which are constantly removing the old materials of the system as fast as the new deposits are supplied.

The change of arterial into venous blood, is not referable either to the artery and vein, any more than to the capillary or absorbent; for indeed, when the circulation is stopped in a limb, its venous hue may be owing to the capillaries supplying the elements, which carbonize the blood in their ultimate action with the absorbents.

The great branches of the arteries, veins and absorbents,

together, probably, with the brain and nerves, are all subservient to the functions of the capillary system; while the phenomena of health and disease, the actions of the therapeutical agents, and the processes of nutrition and generation, may all be traced to their origin in the capillary system.

Of the Veins.

The veins are those elastic membranous tubes, which convey the blood from all parts of the living system to the right auricle of the heart, for the purpose of being submitted to the action of the lungs.

They not only convey the refluent blood, which has been distributed throughout the organismus for the purposes of the animal economy; but also the various products of absorption, poured into them by the main trunks of the absorbents. The flow of the blood in the veins is slower than in the arteries, and it will be found that the capacity of the veins is much greater than that of the arteries.

The arteries of a middle size, as those of the leg and fore arm, have each two deep-seated veins accompanying them; besides which, there is a set of superficial veins which take a subcutaneous course, without having any corresponding large arteries.

The proportion of venous to arterial blood, is calculated to be nine parts venous to four arterial.

The veins are composed of two coats: the *external elastic coat,* is formed of longitudinal fibres, which may be readily observed by slitting up a large vein and exposing it to the light of the sun's rays. The muscular contraction of the veins is but slight, a very few fibres only having been discovered, and these in particularly isolated situations. Hence the veins readily collapse, wanting that elastic distention which characterizes the open state of the arteries.

The *internal* or *membranous coat,* is somewhat similar to that of the arteries, but is not so strong, yet is so dense as to preserve the blood within the vessel, and to prevent its transudation. It differs materially from the inner coat of

the arteries, in being furnished with numerous valvular folds.

These valves occur in pairs, and are each of a semilunar figure, the convex margin being attached to one half of the circumference of the vein. As the blood flows towards the heart, the valves are pressed against the sides of the vessel; but upon any reflux, they quit the sides, open and press against each other, so as effectually to prevent regurgitation. It will therefore be found, that the valves are most numerous in those situations in which the veins are particularly exposed to the pressure of muscular action, and consequent regurgitation of the blood. Thus they are numerous in the extremities, particularly in those veins which are deep-seated, and less numerous in those which are superficial. They are also found in the iliac veins, in the veins of the head and neck, but not in the venæ cavæ, or the veins of the abdominal viscera. Besides this obvious use of the valves of the veins, they serve to divide the length of the column of blood, and thus to diminish its pressure on the sides of the vessels. This is very obvious in cases of varix, when, from pressure, the vein becomes so much enlarged as to prevent the complete adaptation of the valves; the column of blood becomes continuous, and very much increases the enlargement of the varix.

The veins, like the arteries, have been divided into two sets, the serous and the sanguineous; but, as we have observed respecting the arteries, this division has originated in erroneous suppositions.

The origin of the veins corresponds, in a great measure, with the terminations of the arteries.

First, by direct communication with the *termination of arteries.*

Secondly, from each other, by *anastomosis;* this mode of origin is much more frequent than with arteries; and indeed is so numerous, that when a large vein is compressed, anastomosing branches very readily carry on the circulation.

Thirdly, from *sinuses,* as in the vessels in the cranium.

Fourthly, from *cells*, as in the penis, spleen, &c.

Fifthly, from *glands*, and the general distribution of capillary structures.

Much speculation and controversy have arisen respecting the cause of the venous circulation.

Among numerous hypotheses upon this subject, that which assigns a considerable power of elasticity to the action of the heart itself, is particularly observable. When the heart, by its powerful muscular contraction, has forced the blood from the ventricles into the arteries, the cessation of that muscular effort must be followed by a degree of relaxation, which restores the heart to the state in which it was previous to its muscular contraction; and this is probably justly attributable to the elasticity of the organ itself, assisted by the particular tortuous arrangement of its muscular fibres; or, if not to be attributed to elasticity, it must depend on the muscular contraction of the right auricle, which, being stimulated by venous blood, or nervous influence, excites its contraction in like manner to the contraction of the ventricles excited by the arterial blood to force the blood to the arteries. But in answer to this it may be said, that the right ventricle cannot be stimulated by arterial, as it contains venous blood only: this is true; but the main contraction of the ventricles is resident in the left ventricle, the right being, as it were, superadded or subsidiary to the contraction of the left, with which too its fibres intermingle; and the excitement of the arterial blood of the left, may therefore be sufficient to act upon both ventricles at the same time, independent of the venous contents of the right ventricular cavity.

The auricles have probably an action which draws the blood from the veins, similar to the motion of a piston; at least, it must act in opposition to any effort which would tend to form a vacuum: at the same time, some power may be attributed to the momentum of the blood itself, which, however slight, must be in favour of the auricle. The ventricles have only to exert power enough to draw the blood from the auricle into their own cavities,—a distance so short,

that the elasticity of its muscular fibre is probably quite sufficient for the force required.

Bostock seems to consider that anatomy affords no data whereby we can explain the heart's action (*vide* p. 338. Vol. I. *Syst. of Phys.*); but from an examination of the arrangement of its structure, I am led to consider that its function may be fully accounted for.

The ventricles contract simultaneously, and are so constructed that the stimulus of the arterial blood exciting the left ventricle necessarily operates upon the right, which is so attached that the two ventricles cannot perform a separate action. Had the ventricles been attached to the auricles in the same manner as one ventricle is attached to the other, their contractions would have interfered with each other; the muscular arrangement of the auricles form, therefore, detached pouches, capable of a full contraction, independent of their attachment to the ventricles, and sufficient to draw the blood into them in its passage to the ventricles. The muscular parietes of the right auricle is stronger than the left, in opposition to the muscular parietes of the left ventricle, which is stronger than the right, in each instance being in proportion to the extent of force required in the distance of the motion of the blood.

The flow of blood in the veins, regarding them as mere hydraulic tubes, influenced by the pressure of the atmosphere acting on the weight of the column of blood, together with the elasticity evinced in their external coats, shews that the veins are capable of maintaining a column of blood a few inches above the heart:—this is according to the experiments of Dr. Arnot. Such an hydraulic influence must facilitate the contraction of the right auricle, by lessening the force necessary to fill it with blood; but it must be acknowledged, that whether hydraulic or other mechanical powers assist or not in the circulation, they are all regulated in the nicest manner by the vital influence, adapting the pressure of the vessels upon their contents, and regulating the number of the pulsations themselves; and while such an influence, evidently in

constant operation, exists, we know not to what extent mechanical principles can be admitted as influencing vital action.

The motion of the blood in the veins near the heart may be observed in the living animal to consist of alternate states of distention, and collapse: when the auricle contracts, the cava is suddenly distended; and when the auricle receives the blood, the vein is as suddenly collapsed.

Of the Circulation of the Blood.

By the circulation of the blood is meant the course which this fluid takes through the heart, lungs, and blood-vessels of the body; and since the time of Harvey, in the year 1628, it has been ascertained that it is constantly flowing in the same course, and tending toward the same point from which it began. This discovery of the circulation of the blood formed a most important era in medical science, and, indeed, immortalized the name of our countryman.

The term circulation, used absolutely, designates the course of the blood through every part of the body; while the use of the term *greater circulation*, designates the passage of the blood from the left side of the heart, through all the arteries, to be returned to the right side by the veins; while the circulation through the lungs, from the right ventricle to the left auricle, is implied by the term, *lesser circulation.*

Two functions are therefore performed by the heart's action, one to propel the carbonized blood into the vessels of the lungs, and the other to propel the blood, when decarbonized, into the vessels of the whole system; hence both the heart, as an organ, and the circulation of the blood are said to be double, and the terms *pulmonic* and *systemic* have been given to each:—the right auricle and ventricle for the pulmonic, and the left auricle and ventricle for the systemic circulation.

The grand object of the circulation of the blood is to submit the contents of the veins to the action of the lungs,

in order that it may be changed to arterial blood; or, in other words, that venous carbonized blood may be freed from that noxious substance, carbon, by a process which appears to require the fluid to be submitted to the influence of the atmospheric air in the act of respiration.

To trace the blood through its progress for this change we commence with it in its carbonized state, brought to the heart by the veins, united in their main trunks, the ascending and descending cavæ, and terminating in the right auricle.

The circulation of the heart then commences by the right auricle becoming distended to receive its blood, which immediately passes into the right ventricle, from the relaxation of the parieties of that cavity upon the cessation of its last muscular contraction.

Probably, now, from the stimulus of the presence of this blood, and certainly from the simultaneous contraction of the left ventricle, the cavity of the right has its capacity diminished, and its contents propelled partly by the septum cordis, assisted by the contraction of its own anterior wall. The blood being thus compressed would have a tendency equally to flow back again into the right auricle as into the pulmonary artery, but for the tricuspid valve, which checks its course in that direction, and therefore it flows into the pulmonary artery. During this contraction of the *right* ventricle another circumstance has to be considered besides the propulsion of its own blood, namely, that it has formed a fixed point for the muscle of the right auricle again to distend it, for its reception of the next portion of blood brought to it by the venæ cavæ.

To continue the passage of the blood through the pulmonary artery, we are to suppose this vessel to contract immediately it has received the blood from the right ventricle. This contraction has a tendency to send the blood back again to the right ventricle; but a barrier, the semilunar valves, oppose this course, and therefore it is propelled into the lungs, there to undergo the process of decarbonization.

Having undergone this process, by what power are we to

suppose the blood is forced from the lungs to the left auricle? The answer, I believe is, and founded upon anatomical investigation, that upon the last contraction of the left ventricle, the muscles of the left auricle gain a fixed point, from which the fibres are enabled to expand the auricle; and assisted by the action of the lungs the blood, upon the principle of suction, is drawn through the pulmonary veins into it.

The cessation of the left ventricle's action, upon the same principle, conveys the blood into that cavity; which seems to be evinced by the circumstance, that had the auricle's contraction propelled it, it would have had an equal tendency to send it back to the lungs as to the ventricle, against which there is no valvular apparatus in the veins.

It is the left ventricle's turn again to contract, which it does; and being prevented by the mitral or bicuspid valve from forcing the blood retrogradely into the left auricle, it is driven into the aorta, to be distributed throughout the whole living system.

The circulation is then continued in the capillary system, by a contractile power of their own, which does not terminate until the blood enters, in its carbonized state, the veins which terminate in the venæ cavæ, from whence we commenced.

In this description of the adult circulation, we see that the change from venous to arterial blood, is effected by the intervention of respiration and the action of the lungs.

But the case in the fœtus is very different, in which the act of respiration does not take place in the lungs.

The Process of the Blood's Circulation in the Fœtus.

The blood is conveyed from the mother by the umbilical vein into the fœtus, by passing through the umbilicus and fascia transversalis to the exterior surface of the peritoneum; it then changes its course and passes upwards, continuing to the free edge of the broad ligament to the notch of the liver, and there immediately enters the longitudinal fissure, along which it is directed backwards as far as the transverse

fissure; here the vein divides, sending one branch, which conveys (supposing the quantity of blood contained in the umbilical vein as four), three-fourths to the vena portæ; while the remaining one-fourth proceeds backwards in the ductus venosus, along the continuation of the longitudinal fissure to the left of the lobulus spigelii, and empties itself into the ascending or inferior cava, where the four parts meet again, in consequence of the vena portæ having its blood conveyed towards the heart by the venæ hepaticæ, which also terminate in the inferior cava. The four parts of blood, therefore, which had been originally sent by the mother through the umbilical vein, are now conveyed by the inferior cava into the right auricle of the heart; one half of which we will suppose passes directly through the foramen ovale into the left auricle, while the other half passes through the right auriculo-ventricular opening into the right ventricle. This cavity is contracted, and its blood forced into the pulmonary artery; here it divides—one half of it, making one-fourth of what the right auricle contained, is conveyed through a vessel of communication between the pulmonary artery and aorta, which is termed the ductus arteriosus; while the other one-fourth passes into the lungs of the fœtus, and without undergoing the change of adult blood, is returned by the four pulmonary veins into the left auricle. This one-fourth meets the half of the blood which had passed from the right auricle into the left, through the foramen ovale, and the three-fourths are now propelled into the left ventricle, from whence they pass into the aorta, and join with the one-fourth that had passed through the ductus arteriosus from the pulmonary artery into this vessel, and by it, the whole original quantity is distributed throughout the system of the fœtus, to answer all the purposes of nutrition and growth.

A large proportion of the blood is however, returned to the mother by two large vessels, which are given off by the internal iliacs of the fœtus, and are termed the umbilical arteries. They ascend from the internal iliacs by the sides of the bladder, between the peritoneum and parietes of the

abdomen, and reaching the umbilicus, come in contact with the umbilical vein; thus completing the umbilical cord.

This cord, it will be seen therefore, is composed of the umbilical vein, which conveys the blood from the placenta to the fœtus, and of the two umbilical arteries, which return it: in this course the vessels are extremely tortuous, and of a considerable length, which varies however from two to even four feet in extent.

The three vessels which enter into the composition of this cord, or navel-string as it is sometimes termed, are bound together by a firm interstitial, cellular-gelatinous substance, which probably answers the same purpose as cellular membrane, and supplying them with vasa vasorum; the whole being surrounded by a sheath from the ammion. The cord is not believed to contain nerves, from the circumstance, that its division neither gives pain to the mother or child. Nor have any absorbents hitherto been traced to it.

The union between the mother and fœtus takes place in the placenta; but it is a remarkable fact, that this union is not to be detected by the finest injections; although, however many young there may be, every fœtus must have its own placenta. The blood brought from the fœtus to the placenta by the umbilical arteries, ramifies within the placenta together with the umbilical vein, until becoming capillary, or infinitely minute, branches unite in that state. The part of the placenta attached to the uterus, is not supplied with blood in the same manner, but derives it from the vessels of the uterus. Injections will not pass from the uterine to the fœtal part of the placenta, nor will it in the opposite direction. There can be no doubt, however, that nourishment is supplied to the fœtus by some communication in the placenta, which has not hitherto been discovered.

Of the Absorbents.

The absorbents form the third description of vessels circulating the fluids of the living system.

They are more delicate, thin, and transparent, than either

the arteries, or the veins. They are distributed in every part of the system, and form an abundant portion of the capillary order of vessels.

They are termed absorbents, from the power they possess of imbibing different substances which are exposed to the action of their open mouths, and conveying them to the current of their circulation; which power is named absorption.

This function of the absorbents is exerted in two very opposite ways: in one, they convey matters of nutrition; in the other, their action is wholly excrementitious, in which they remove the worn out solids of the system in the process of growth.

No difference has been hitherto discovered in the structure of either the recrementitious or excrementitious absorbents.

Their appearance is nearly transparent; but frequently they assume a greenish hue, from a portion of bile mixed with the fluids they circulate.

They are composed of two coats, both very thin, transparent, and highly elastic. They are firm and dense, and are able to support a column of mercury twice as high as would rupture the arteries of the same calibre. Their elasticity is shewn by the distance to which they will eject their contents when one of them is punctured.

Their inner coat, like that of the veins, forms numerous semilunar valves, disposed in pairs, similar in structure to the valves of the veins; but, unlike the veins, are constant in their appearance in every part of the absorbent system: the valves are also more numerous, four pairs, and often more, occur in the space of an inch; and between the valves the absorbent swells into a sort of pouch or reservoir, which gives the vessel a knotted appearance, by which it is distinguishable from a vein when injected. The fluids the absorbents circulate, pass from their smaller into their larger branches, and are prevented from regurgitation by their numerous semilunar valves.

The first and most obvious function of the absorbents, is,

that of conveying the nutritious products of digestion into the blood, to supply the waste occasioned by the various deposits in the distribution of the arterial circulation. Formerly these vessels were designated by the name of lacteals, from the whitish milky appearance of the chyle upon its first absorption; while the remaining portion arising throughout the rest of the system, were termed lymphatics: but they are all now usually designated by the term absorbents.

The second remarkable function of the absorbents, is in removing the solids of the body, which appear, after a certain period, to be no longer fitted for the purposes of life; this action is evident more particularly in the process of growth, which does not consist in a mere addition to the particles constituting the organismus, but in the constant deposition of new matter and the removal of the old, by the process of absorption. Hence it will be found, that the absorbents are more developed in young persons and much more active, than in the adult; at the adult period, the arteries and absorbents are equal in their action; while in old age, the arterial vigour is slackened and the whole system enfeebled, but the action of the absorbents still continues, and is the cause of that shortening of stature and general emaciation, which usually accompany old age. The cuticle, the nails, and the hair, are probably the only exceptions to this general action of the absorbents: they also are subject to the general law here mentioned, but in a different mode from those structures removed by absorption, as they appear to undergo a species of desquamation, in which their old growth separates as the new is gradually formed; and in the instance of the hairs of the head, when the vessels of their roots have lost their vigour of action, they turn grey, or separate altogether, producing baldness.

The absorbents are also active agents in removing the accumulations of fluids secreted in serous cavities. To this agency may be attributed the rare occurrence of dropsical effusions, which otherwise would be constant: and when these diseases are relieved by the agency of medicines, it is

the absorbents which are excited to act more abundantly in removing the accumulated fluid.

A fourth function has been assigned to the absorbents, in their operation upon certain of the secretions, in fitting them more completely for the purposes they are destined to perform. Thus the bile is first received into the gall-bladder in a bland and mild state, and is there subjected to the action of the absorbents in the coats of the viscus, which take up the more watery parts, leaving the active principle of the bile in a concentrated state, and better fitted for its destined uses in the animal economy.

In their distribution the absorbents are similar to the veins, and in general accompany them, both in a deep-seated and in a superficial course. Thus the superficial veins of the extremities, the head and the neck, have absorbents accompanying their larger branches; while to the deep-seated veins there are generally two or more, excepting in the cavity of the abdomen. Here the absorbents quit the veins, and often assume an arborescent or cellular distribution. In the upper part of the abdomen, the absorbents unite, and entering the thorax through the diaphragm, in the aperture which admits also of the passage of the aorta, they form a vessel which gains the name of the *thoracic duct.* This vessel extends up the fore part of the spine, until it reaches the upper part of the thorax, between the aorta and vena azygos; it then inclines to the left side of the chest, passing into the cervical region to terminate in the veins of the neck. Previous to the commencement of the absorbent thoracic duct, it forms a remarkable enlargement, which is termed the *receptaculum chyli.* This is placed immediately behind the right emulgent artery.

The absorbents may therefore be considered as the ultimate channels of the food in the process of digestion, previous to its reception as a constituent of the blood itself. The food taken in by the mouth is digested in the stomach, and from thence conveyed into the intestines; from whence the absorbents take it up in the form of chyle, to be conveyed, as above stated, into the veins.

The origin of the absorbents, as may readily be conceived, must be infinitely various. First, from the inner surface of intestines, for the purpose of absorbing chyle, where they are innumerably distributed on the villi, or velvet-like surface of the inner coat of the intestine. Here they commence in open mouths; and Bell has asserted, that he has counted fourteen on a single villus, and compares them to the puncta lacrymalia of the eye.

From this peculiar formation, various conjectures have arisen to account for the action of the absorbents in taking up chyle only, without any mixture of the excrementitious matter of the alimentary mass. The only way to account for this action is, by supposing that the mouths of the absorbents are incapable of being stimulated to act by any particles but those of chyle; in fact, that they possess a sort of choice, by which they reject the excrement and take up the true nutritious part—the chyle. We are equally at a loss to account for the action of the absorbents in all the other parts of the system; in each of which, excepting the cuticle and its appendages, and perhaps the enamel of the teeth, they appear to act with a constant and irresistible force, removing even the solid structures of the bones.

Two abundant sources of origin give rise to this general distribution of the absorbents; one from the surface of the body, in the common integuments; wherever the veins are large, there the absorbents are abundant and large also. In the scrotum they may be readily injected, by first puncturing the skin, and extravasating some quicksilver. It is from this source that mercurial friction produces such ready effects throughout the system; the absorbents take up the mercury, and convey it to the blood.

The second source of origin of the general distribution of absorbents, is in the cellular and membranous tissues throughout the whole organismus; in stating which, we have probably included every structure which can be named, as cellular membrane is more or less a component of every other structure.

A fourth origin is however yet enumerated by anatomists: this is from the excretory ducts of glands. If the hepatic duct is tied, bile will be abundantly absorbed by the neighbouring absorbents, and the animal becomes jaundiced.

The terminations of the absorbents next claim our attention; and in connection with the recent discoveries and experiments of anatomists, forms an interesting field of physiological research.

The termination of the absorbents at the thoracic duct has already been mentioned: but besides their main trunks, the absorbents have innumerable terminations in veins; this is readily seen by means of injections, and an examination of various substances submitted to the action of the absorbents by direct experiments on animals.

When quicksilver is injected into the absorbents of the intestinal canal, it easily reaches the mesenteric veins and the vena portæ; the communication taking place in the mesenteric glands. This explains the appearance of white chyle, or a substance resembling chyle, which has been frequently observed in the blood of the vena portæ soon after taking food.

It therefore is concluded, that although the thoracic duct forms the main channel for the flow of the chyle, and other substances taken up by the absorbents in the intestines to be carried into the blood; yet a certain portion of those nutritious substances are also conveyed by the absorbents into the mesenteric veins, and by the vena portæ, to be subjected to the influence of the liver.

It must here be remarked, that it appears that the absorbents of the intestines have not only a peculiar power of selecting the nutritious particles constituting chyle, but that they reject other substances which find their way into the absorbents in different situations. Thus odoriferous coloring, and certain saline substances, were found by Tiedemann and Gmelin to be conveyed into the blood of the vena portæ, when they could not be detected in the thoracic duct with the chyle.

In the same manner, the presence of indigo, gamboge and alcohol, cannot be detected in the lacteals or thoracic duct, when they may be abundantly manifest in the blood of the mesenteric veins and vena portæ. From these remarkable circumstances a question arises, as to what means the passage of these substances is effected to the blood, as they cannot be traced by the way of the lacteals and thoracic duct.

In another experiment it was found, that when sulpho-cyanate of potash had been given to a dog, on opening a branch of the mesenteric vein the saline matter was perceived, but none could be discovered in the chyle.

It has therefore been concluded, but of course only upon conjecture, that the veins either absorb heterogeneous substances directly by their radicles from the intestines, or that they have a communication with the absorbents in the absorbent glands; or that absorbents arising from the intestines terminate in the veins.

That the absorption from the whole system finds its way into the veins by means of the thoracic duct alone, seems highly improbable, if it were merely from the circumstance of its size, which can scarcely be considered as sufficient for the quantity of fluids absorbed; particularly when their action is increased, as under the influence of certain diseases, and the effects of particular medicines.

Several interesting experiments have been performed by Professors Mayer and Bonn, which throw considerable light on the comparative powers of the absorbent system in different situations of the body; and offer a strong proof of the uniform distribution of these vessels throughout the greater part of the living system.

They found that fluids injected into the lungs by an opening made in the trachea, were absorbed more readily in adult than by young animals; and conclude, that the veins must absorb, as these fluids may be detected in the blood before they can be detected in the chyle; and in the left auricle and ventricle of the heart, long before the least trace of them

can be detected in the right, and even when the thoracic duct has been tied.

The prussiate of potash injected into the lungs, is first detected in the arterial blood of the heart and arteries; then, if the injection be continued, in the blood of the veins; in the urine, and substance of the kidneys and bladder; in the serum of the pericardium, of the pleura, and the peritoneum; in the synovia, in the milk, and membrane under the skin. After some hours, it may be detected in various solids; the cellular tissue throughout the whole body; in the fat, the serous and fibrous membranes, the aponeurosis of muscles, the tendons, the dura mater, periosteum, &c.; the coats of the arteries and veins, and the valves of the heart; the heart itself, the lungs and the kidneys.

The parenchyma of the liver and spleen cannot be colored blue, neither the substance of the bones and their marrow. The substance of the muscles, and the substance of the brain, spinal marrow and nerves, exhibit no change of color from the muriate of iron.

When prussiate of potash has been given to a pregnant animal, it may be detected in various parts of the fœtus; which proves the fact, that the fluids of the mother deposited in the tissue of the placenta, are absorbed by the vessels of the fœtus, and most probably by the veins.

Considerable light has been thrown upon this interesting subject, by the experiments of M. Magendie and Fodera. Magendie observed that venesection increased the process of absorption in a remarkable degree; and therefore concluded, that a state of plethora, whether real or artificial, by distending the blood-vessels, put an end to the process of absorption, or nearly so. This theory, however, he carried so far, as to consider the veins alone to absorb, and to deny the process of absorption to any other vessels excepting the lacteals, which he considers possess the power of absorbing chyle only; and refers the whole to the mere mechanical process of capillary attraction.

M. Fodera considers, that exhalation and absorption may

be referred to two processes, which he terms transudation and imbibition; both processes taking place from the capillary attraction of the parietes of vessels, owing to their porosity; operating, in the first case, from the interior of the vessel to the exterior, and in the second, from the exterior to the interior.

These conclusions are drawn from experiments, which shew a power in veins, arteries and intestines, of communicating the effects of poisons, whether placed on the outer surface of an isolated portion of them, or injected into their cavities, carefully secured on either side of the injection.

Gases enclosed in a portion of intestine taken from a dead animal, and placed on the surface of the intestine of a living animal, will be all absorbed by the living, and its poisonous effects made apparent. If in a living animal an artery or vein is exposed, an oozing is observed, which increases if the vessel is tied with a ligature.

The experiment on which M. Fodera founds his theory of transudation of liquids from the interior or exterior of vessels or membranous structures is the following:—A portion of the intestine of a rabbit was filled with a solution of prussiate of potash, and plunged into a solution of hydrochlorate of lime; and into another portion of intestine he introduced some hydrochloric acid, and surrounded it with sulphuric acid; then he filled a bladder with tincture of turnsol, and placed it in a solution of gall-nuts.

Some time afterwards, upon examination, the following was the result:—In the intestine containing prussiate of potash, hydrochlorate of lime was detected; in that containing hydrochlroric acid, sulphuric acid; and in the bladder containing tincture of turnsol, gallic acid was detected; while in the liquids in which they had been immersed he detected prussiate of potash, hydrochloric acid, and tincture of turnsol.

A similar change of substances may be effected by the pulmonary vein and the trachea of a sheep, injecting hydrochlorate of barytes in the former, and hydrocyanate of potash

into the latter; the hydrochlorate of barytes will be found in the bronchi, and the hydrocyanate of potash in the pulmonary artery.

In the living animal, when an injection of gall-nuts or sulphate of iron is thrown into the cavity of the peritoneum or thorax, they may be detected, in the first instance, in the thorax, in the second, in the peritoneum; and the black color formed by the transudation, though not capable of detection in some instances for more than an hour, may be rendered almost instantaneous by the influence of galvanism.

This latter very interesting experiment is performed by placing a cloth, wetted with a solution of sulphate of iron, externally; and internally, in the bladder or intestine of a rabbit, a solution of prussiate of potash; the first communicating with an iron wire, the latter with a copper wire. Matters thus situated, if the communication be made between the iron wire and the positive pole, and between the copper wire and the negative pole, the tissues of the organs become of a Prussian blue color; but if the stream be reversed, the color appears on the cloth. These experiments were varied in many ways, with similar results, and clearly prove the wonderful facility of communication which exists in the capillary system of vessels; but does not, in my opinion, clearly establish, that absorption can be referred to any other order of vessels than the absorbents.

There is yet another extensive mode of termination to the absorbents, namely, in numerous small glands, termed the lymphatic or absorbent glands, which are generally dispersed in clusters throughout the system; they are, however, more numerous and of larger size in particular situations: as in the neck, and around the base of the jaw and occiput; in the arm-pits, and along the course of the larger vessels, as the aorta and iliacs. In the groin there are two sets; one close to Poupart's ligament, and the other above it. They are found at the roots of the different viscera, where their blood-vessels enter: they are very numerous in the mesentery. Like the absorbent vessels, they have a superficial and a deep-seated

arrangement: the superficial set are most liable to scrofula; but if schirrus begins in the throat, the deep-seated are most liable to be affected. These glands are of a reddish color, and of an amygdaloidal form: the absorbents enter them, and divide into numerous minuter vessels, disposed within the substance of the gland; convoluted, and coiled back upon themselves in various ways. The gland is composed of numerous small cells, filled with a whitish fluid, which the absorbents take up and convey by their branches which pass out from the gland: the absorbents entering are termed *vasa inferentia*, while those which pass out are termed the *vasa efferentia*. Besides these, several absorbents pass over the exterior of the gland, and are capable of carrying on the circulation when the gland itself is inflamed or swelled, which is a very frequent occurrence.

The exact office of the lymphatic gland is not well understood; it may however be observed, that the contents of the absorbents are every where submitted to the action of these glands before it enters the blood; and in some instances, as in the mesentery, appears to pass through several of them before it reaches the thoracic duct, to terminate in the blood-vessels. It has been observed, also, that the fluid in the vasa efferentia is more coagulable than in the vasa inferentia; the absorbent glands may, therefore, perform the office of assimilating their contents, so as to approximate them to the nature of the blood. The absorbent glands also exert an office upon the matters absorbed, which separates deleterious substances: thus, the venereal virus will be arrested by the glands of the groin; and until they, in consequence, become themselves diseased, the poison is not conveyed further into the system.

The serous fluid or lymph contained in the absorbents was considered by Haller to resemble the serum of the blood; it is coagulable by heat, alcohol, and acids. When exposed to the air, on cooling, it separates into two parts; one which forms a gelatinous coagulum, and sinks to the bottom; while the other is much more abundant, fluid, and

floats at the top. The coagulated mass is semitransparent, and of a pinkish color; it possesses different properties when the food has been vegetable or animal: from vegetable food it is transparent, contains carbon, and is not easily passing into a putrid state; from animal food it is milky, very putrescent, and besides albumen, contains a matter resembling cream, furnishing carbonate of ammonia by distillation.

The absorbents are supplied similar to the arteries and veins with vasa vasorum, which may be traced on the thoracic duct; their glands have numerous arteries and veins distributed to them, and from them derive their reddish appearance.

Having now finished the pathological considerations respecting the organs destined to circulate the fluids of the body, it will now be proper to treat, in a cursory manner, the pathological facts connected with them.

In speaking of the situation of the heart I have already stated, that its base is directed backwards towards the fourth dorsal vertebra, remote from the sternum; and that its apex projects forwards, so as to be felt striking against the parieties of the chest, in the space between the cartilages of the fifth and sixth ribs: that the alternate contraction of the auricles and ventricles is accompanied by a peculiar sound; and that the movements of the heart observe a regular order of succession. Now as these circumstances may all deviate, more or less, in consequence of disease, it becomes of the greatest possible importance, carefully to investigate and to remember the phenomena usually presented, in all these respects, in a state of health.

It is in fact upon a knowledge of these phenomena, depending upon the healthy action of the heart, that has lately been founded a novel but ingenious mode of investigating the diseases of this organ. This is by means of what has been called *auscultation;* which may be either immediate, by applying the ear to the chest; or mediate, and performed by means of a hollow tube or cylinder, called a *stethescope*—

an instrument invented by the late celebrated physician Laennec.

It is not to be expected that in this work I should enter into detail on this subject; but I may observe, that the derangements of the heart, which are investigated and determined by the aid of auscultation, are referrible to the four following circumstances :—*First*, the extent to which its pulsations are audible; *secondly*, the impulse or force with which it appears to strike the parieties of the chest; *thirdly*, the sounds emitted during the contraction of its auricles or ventricles; and *fourthly*, its *rhythm*, as it has been called; or, in other words, the order and succession, as well as the duration of its respective movements.

It is also right to mention, that this mode of investigating disease was, by the same distinguished physiologist, applied with extraordinary success in explaining the diseases of the lungs, and of the contents of the cavities of the chest generally.

Auscultation will, by habit, acquaint the medical man with the knowledge of which of the cavities of the heart emit each particular sound. In a healthy subject, if the stetheseope be applied either between the cartilages of the fifth or sixth ribs, or upon the inferior extremity of the sternum, a distinct sound is emitted; or rather, it may be described as a double sound, which correspond with the arterial pulse. One of these sounds is described by Laennec as being "clear and rapid, and somewhat resembles the sound produced by the valve of a pair of bellows: this corresponds to the contraction of the auricles. The other is more dull and prolonged, coinciding with the beat of the pulse, and with the shock communicated to the parieties of the chest by the motions of the heart: this indicates the contraction of the ventricles." The sound produced by the right side of the heart, is most audible at the inferior extremity of the sternum; and in the interspace of the cartilages of the fifth and sixth ribs, that of the left side.

Bearing in mind the situation, action, and sounds of the

heart in its healthy state, you will, in some measure, be able to recognize and appreciate those deviations indicative of disease. The heart, like other organs of the body, may be involved in merely functional, or it may be the subject of organic disease: the former is by far the most frequent, its frequency being nearly in the ratio of the nervous susceptibility of the individual. Hence the great prevalence of functional disorder of the heart in delicate hysterical females; and hence those occasional alarming disorders of the heart incident to dyspeptic and hypochondriacal men. In these cases, whether arising from mental emotion or from sympathy with some other disordered part or organ of the body, the action of the heart is observed to be suddenly affected with violent inordinate action, striking the ribs with great violence, and apparently extending its impulse over a very considerable space of the chest; at other times, under such circumstances, instead of palpitation, there is merely what appears to be a morbid sensibility of the breasts, so that without any great violence of action or irregularity, the patient is conscious of each impulse of the heart, which we know is not the case in perfect health; whilst in other instances, again, the heart, instead of promoting its natural rhythm, appears suddenly to stop for the period of one beat, and thereby to give rise to what has been called intermission of the pulse; and lastly, the heart may be affected with severe pain, or what has been called neuralgia; a pain not necessarily accompanied even by irregular action, but a pain unfortunately not unfrequently associated with hopeless organic disease of the organs.

Now in such cases as these we find the nature of the disease indicated, or at least rendered probable, not only by the sex and state of constitution of the individual, but by the absence of those signs by which organic disease is usually recognized.

It is hardly necessary to observe, with respect to organic disease of the heart, that it is various, and that it may affect any of the tissues entering into the composition of the organ; or what is more common, it may affect one of them

at the commencement, and then extend to the rest, either from continuity or from the disturbance of the peculiar function of any particular part.

The pericardium is subject to inflammation, and very frequently following rheumatic affections, leading to the belief that a real matastasis occurs. The symptoms accompanying peracarditis frequently offer considerable difficulties to the formation of a just diagnosis; as the heart itself, pleura, and even the lungs, may present signs of disease.

The heart is sometimes the subject of general increase of the substance of its muscular parieties, without any dilatation of its cavities: this is termed hypertrophy of the organ, and may affect either ventricles, auricles, or both; but most frequently the former only.

The converse to hypertrophy is that disease, which, in the place of the great thickening of the muscular parieties of this organ, exhibits on inspection a dilatation of its cavities, and a corresponding thinness of its walls. This disease has been termed by Corvisart, passive aneurism; and here, in most cases, is subjoined a disease, which may however exist, independent of dilatation—a softening of its muscular structure, known by the expressive term of a "flabby heart."

Besides those diseases which affect the structure of the heart generally, we may mention those equally important affections, in which the different valvular apparatus of the organ become obstructed in the performance of their peculiar function by ossific deposit, or changes consequent upon acute or chronic inflammation.

The valves of the left side of the heart are more frequently the subject of these organic alterations, than those on the right; so frequently, in fact, found in the old subject, as almost to justify the opinion, that they are amongst the natural changes of old age, than the result of any definite disease. But the valves at an earlier period of life become thus affected; such thickening takes place, either around the auriculo-ventricular opening, or at the ostium aortæ, as

not only to diminish the proper area of these openings; but even sometimes, as related by Laennec, as almost totally to obstruct them. The result of this would be, first, to produce a dilatation of the left ventricle, from the inability of the organ to discharge its blood through the diminished opening; and further, to increase its muscular thickness, from its frequent efforts to carry on the circulation.

It would be obvious, from what has been said of the valvular diseases of the left side, that dilatation and hypertrophy of the right, would necessarily occur under similar disorganization of its valve.

It is right however to say, that the opening of the pulmonary artery is much more rarely diminished in diameter than that of the aorta; and that instances are but seldom met with of bony and cartilaginous deposits in the tricuspid valve of the right auriculo-ventricular opening.

But besides the diseases of the valves, various other causes which might impede either the passage of the blood through the general or pulmonary circulation, would necessarily produce derangement of those cavities destined to transmit each portion of the circulating fluid.

The heart is liable to rupture of its parieties, from inordinate muscular action: this disease is, fortunately, so rare, as to have induced Laennec almost to doubt its existence. Some well authenticated cases have, however, lately been recorded by Dr. Farre, in the first number of his "Journal of Morbid Anatomy;" which would lead us to believe, that softening of the heart had previously taken place, and that during violent moral excitement, it had given way under the muscular impulse. Previous ulceration sometimes leads to the same result.

Ossification of the coronary arteries, is supposed to be the common cause of the disease termed angina pectoris; although there is reason to believe, that it is not unfrequently a consequence of disordered function.

Malformations of the heart most frequently tend to the intermixture of the venous and arterial blood; this may arise

either from the permanence of the foramen ovale, an unnatural opening through the septum cordis, or pervious state of the ductus arteriosus. The blue color of the skin, well known as the morbus cæruleus, and the immediate effects on respiration, and sometimes even syncope, produced by excitement, are the most common symptoms arising from such causes.

There are certainly no circumstances connected with disease, or accident, which so promptly require surgical assistance, or are so appalling to the patient, as hæmorrhages; it would be therefore a great dereliction of my duty, were I to fail giving some account of those diseases which tend to produce this effect, and which have their seat in the blood-vessels.

The arteries, the organization of which I have already given, were described as being composed of three separate coats of different structures, and as being supplied by their own blood-vessels, nerves, and absorbents: hence it must necessarily occur, that they are subject to all the diseases incident to their peculiar textures.

When inflammation attacks an artery, it may terminate, as in other parts of the body, either in adhesion, suppuration, ulceration, or mortification.

It is by the adhesive inflammation that wounds of arteries are repaired after the amputation of a limb, and their calibres become obliterated upon the application of a ligature: also when subjected to pressure from any neighbouring tumour, or from abscess. It is this adhesive process, therefore, which admits of the performance of the numerous surgical operations, and which, in fact, prevents the slightest accident, that may affect an artery or vein, from proving fatal through the hæmorrhage which would otherwise occur.

Inflammation does not, fortunately, often terminate in ulceration of the coats of arteries; and it may be said, perhaps, never to occur, unless there has been some previous morbid affection. The deposition of calcareous substances will sometimes lead to such an ulceration, as completely to

destroy the coats of the vessel, and lead to what is termed a spurious aneurism.

Cancerous and phagedenic ulcers may also give rise to fatal hæmorrhage from the same cause.

The internal coat of an artery, which in structure bears so much resemblance to serous membranes, may be supposed, like them, sometimes to lead to the formation of pus; but which, being immediately poured into the interior of the vessel, would necessarily be washed away with the stream of blood, and therefore could not be detected.

The deposit of bony matter in the coats of an artery, is so frequently found on the examination of old subjects, as to have led some surgeons to consider it a necessary consequence of old age; but it is a change, certainly not invariably attendant on a state of protracted existence. It is sometimes, although very rarely, met with in the arteries of young persons, and seems to be generally produced by excessive stimuli to the action of the heart and arteries, by hard drinking or violent athletic exertion.

Previous to the deposition of earthy matter, there invariably occurs a formation of a substance very similar to cartilage; which, as in the natural development of the osseous system, forms a nidus for the deposition of earthy particles; at which period, the artery becomes opaque, and loses its natural elasticity as well as its semitransparency.

The deposition of bone is sometimes so considerable, as to render the artery a complete osseous tube; while at others, it will form irregular patches only: in either case, it gives rise to a change in the force as well as in the regularity of the circulation; and sometimes to an extent so great, as to lead to mortification in a distant part. Under these circumstances, we not unfrequently find that old people lose their toes, and even their feet.

There is a disease peculiar to arteries, in which they lose their elasticity, and are rendered incapable of circulating their natural supply of blood, by which they become permanently distended. Children are occasionally born with

this defect in the superficial vessels of different parts of their body; and the disease has, from a vulgar notion of its being connected with mental affections of the mother, been termed nævus maternus. This disease varies not only as to its extent, but also as to the structures which it may involve. Sometimes, for instance, it will assume the form of a superficial stain, and appear as if it depended upon some morbid change in the rete mucosum; while at others, it seems to consist of clusters of enlarged anastamosing veins, forming distinct sacs of blood: in some, again, large distended arteries will be found running into the diseased structure; if these formations be cut into, they resemble, in appearance, the interior of the spleen. When nævi are small, and are situated over bone, they may, by the application of pressure, combined with the use of restringent lotions, be altogether removed. Applications of caustic, setons, and even the inoculation of vaccine matter, have all been recommended as means of cure. Where they evince a tendency to enlarge, and become troublesome from their increase, and danger of bursting, extirpation is the only means to be employed for their removal; and this may be performed either with the knife, or by means of ligatures. When they are so large that the surgeon has any reason to fear hæmorrhage during the operation, the ligature should be employed; and particularly when the patient is very young.

Sir Astley Cooper and Mr. Brodie both, I believe, recommend the application of ligatures; but whether these or the knife be employed, great care should be taken, that, in the first instance, every portion of the diseased structure be included; or where the use of the knife is preferred, that it be perfectly extirpated; otherwise the disease will rarely fail to return.

The most important of the morbid changes to which the arteries are liable is, a dilatation or yielding of some part of their structure, constituting a disease which is termed aneurism.

An aneurism may therefore be defined to be a pulsating

tumour, communicating with the interior of an artery, and containing blood.

This disease may attack either the arteries situated within the cavities of the body, or the vessels supplying the extremities or superficial parts. In the former case, the disease is termed an *internal*, and in the latter, an *external aneurism.*

The symptoms which are induced by an internal aneurism, will depend upon the altered function of the viscera, or different organs upon which the tumour may press. The diagnosis will therefore be formed by an examination as to the presence of a pulsating tumour in the course or situation of a large artery, or in the vicinity of those organs, the altered function of which may be explained by the pressure of such a tumour.

In such cases, where an artery cannot be subjected to the application of a ligature between the swelling and the heart, for the purpose of preventing the flow of blood into the tumour, one of two modes of treatment alone can be applicable; namely, either to apply a ligature on the *distal* side of the tumour, with the hope that the inflammation may extend so as to obliterate the aneurism, or merely by palliative means to protract the period of destruction which must follow the spontaneous bursting of the tumour. The means which are employed for this latter object, consist in diminishing the frequency and force of action of the heart and arteries by general blood-letting; this, however, must be done with considerable caution, to an extent merely to produce that object without increasing the irritability of the system, which would tend to increase the frequency of the pulse, although it might diminish the general force of the circulation.

When an external aneurism has formed, it may be known by the appearance of a pulsating tumour in the vicinity of an artery, which may be partly emptied of its blood by pressure on the vessel above it; as well as by its immediately becoming again distended upon that pressure being

removed. An enlarged gland, or any other tumour situated immediately over an artery, may receive such an impulse from the vessel as to lead to some difficulty in the diagnosis; but in these cases, a firm and steady pressure on the tumour diminishes its pulsation: while in aneurism, the same degree of pressure renders its pulsations even more perceptible. In the abdomen, however, there is frequently considerable difficulty in deciding whether the tumour communicates with the interior of the artery; or whether it merely receives an impulse from its contact with the aorta. The position in which you examine your patient, in these cases, will probably lead to the safest and surest mode of forming a diagnosis: first, examine your patient on his back, and try, by different degrees of pressure, to ascertain whether the pulsation be from the blood passing through the tumour, or only communicated by the parieties of the aorta. Then desire your patient to place himself upon his hands and knees, in that position commonly called "*on all fours*," when, if the pulsatory motion of the tumour depends only upon its vicinity to the aorta, it will usually, from its own weight, fall from the vessel, and either entirely lose, or have its pulsation very much diminished; whereas if it be of an aneurismal nature, the pulsation will remain the same.—To return, however, to the subject of external aneurism: being satisfied with the nature of the disease, there is nothing left to be done than to prepare your patient for the operation of the application of a ligature around the vessel, between the tumour and the heart. The mode of performing this operation upon the different arteries in the body, I shall not describe until I speak of the distribution of the arterial system.

To enter into the detail of the progress of aneurism, from its commencement to its termination, is more than the limits or intention of a work on anatomy can admit of. My object therefore, has been that of furnishing as much as would be sufficient to interest the student, and induce him to consult surgical books upon the subject for more perfect information.

Aneurismal varix, is an accident which occurs from

bleeding, and generally in the median basilic vein, the point of the lancet passing through the vein into the artery. The effect of this accident is to produce an adhesion of the two vessels, with an opening of communication between them. In a few days a tumour, about the size of a small walnut, of a bluish color, presents itself, possessing a peculiar tremulous motion, and to the ear communicating a whizzing sound.

This tumour, when pressed upon, disappears; if the vein be compressed above it, the swelling increases in size; and if the artery be compressed in the same situation, the pulsation of the tumour entirely ceases, but returns immediately upon the pressure being removed.

This disease but rarely occurs, and only two cases are recorded as being the result of any other accident than from careless venesection: the one, of a blacksmith's boy, who had the femoral artery wounded, with its vein, by the sharp end of an iron rod: and the other case, was of a dragoon, who received a pistol ball in his right ham, and which, either at the time or from after-sloughing, produced a communication between the popliteal artery and vein. Both of these cases are related by my friend Mr. Hodgson, in his valuable work on the "Diseases of Arteries and Veins."

Such cases will sometimes lead to no inconvenience, but the patient is enabled to follow even laborious occupations, without any other sensation than that of occasional numbness of the affected limb: but, even under such circumstances, the tumour should be defended by mechanical means from external injury; for should the tumour burst, either in consequence of over-distention or of any external injury, the artery must be secured both above and below the opening of communication with the vein.

Compression has also been known, in some cases, to produce an effectual cure, and should therefore always be employed in the first instance; raising the arm at the same time to facilitate the flow of blood through the veins, and making use of such remedies as will tend to diminish the action of the heart and arteries.

Veins are frequently subject to an enlargement or dilatation, from an accumulation of blood, or rather, it may be said, from their parieties not being able to sustain the weight of the additional columnar height which they are required to support, from a want of juxtaposition in the valves rendering them incapable of performing their usual office. This disease is termed a varicose state of vein, and is most commonly observed in depending portions of the body; as, for example, in the veins of the scrotum, and those of the lower extremities.

Under this affection, the veins not only become much enlarged, but excessively tortuous in their course; which seems as it were, by a provision of nature, to serve the purpose of dividing the column of blood, and then of taking off a portion of the accumulated weight from the sides of the diseased vessel.

In such cases, the skin frequently becomes hard and dry, desquamates so as to expose the true skin, and sometimes leads to suppuration, producing hæmorrhage and troublesome ulcers.

Relief may almost always be obtained by placing the limb in an horizontal position, and supporting the veins by the application of a roller; and if ulcers be formed, the black or yellow wash will be found highly efficacious.

As to medical treatment, the bowels should be kept freely open, for obstinate constipation is one of the most frequent causes of the disease; thus we may explain the much more frequent occurrence of this affection in the spermatic veins of the left side, and in those of the left lower extremity, from the accumulation of fæculent matter in the sigmoid flexion of the colon retarding the return of blood through the left iliac vein. The peculiar termination of the left spermatic into the emulgent vein, may also tend to render varicocele more frequent on the left, than on the right side of the body.

The veins, like the arteries, are liable to become inflamed, and are therefore exposed to all the consequences of inflam-

mation. It is the internal coat which is most frequently affected, and particularly after bleeding, when the inflammation will sometimes extend to larger trunks, or even to the membrane lining the cavities of the heart.

The result of inflammation of the internal coat of a vein is sometimes, although rarely, the obliteration of its calibre from the effusion of adhesive matter, so that the vein is converted into an impervious cord: at other times, pus is secreted, which may either be carried into the circulation, or it may induce adhesions in different parts of the vein, so as to lead to the formation of a chain of small abscesses.

My respected friend, Mr. Professor Coleman, has remarked, that when inflammation of the jugular vein follows bleeding in a horse, the inflammation extends in the direction of the animal's head; while, in the human subject, it invariably takes place towards the heart.

But it is also worthy of notice, that such ill effects rarely follow the operation in the horse, unless the pin which is used to stop the bleeding be very improperly passed through the coats of the vessel, instead of including the skin only.

If the inflammation of the veins be not very extensive, strict adherence to the antiphlogistic regimen, assisted by the application of leeches, and the administration of calomel and opium to allay irritability, will usually produce a cure. John Hunter has treated with success a case which appeared as if the inflammation were extending rapidly, by applying a compress on the vein; and thus, by inducing adhesion of its sides, checked the progress of the disease.

When, however, inflammation extends to large veins, and the suppuration is considerable, a very high degree of constitutional irritation is set up, and the patient usually sinks with symptoms very similar to those of typhus fever. This I have frequently seen in cases at Guy's Hospital, where the pupils have wounded themselves in dissection, or in *post mortem* examinations: and on referring to my notes on this subject, I find that those who have fallen victims to this disease, have been generally from abroad, and from warm

climates, in whom we should expect increased irritability, with a diminished power of constitution.

There is sometimes found a general enlargement of all the coats of a vein, giving rise to a distinct fluctuating tumour; this state of dilatation is termed varicose aneurism. Sir A. Cooper, in his surgical lectures, mentioned two such cases that were admitted into St. Thomas's Hospital: the one was situated in the neck of a woman, and its bursting caused her death from hæmorrhage; in the second case, the tumour was situated in the popliteal region of a man who was admitted under the care of Mr. Birch; this tumour pulsated, and the limb was amputated, when it was found to be a varicose aneurism, pulsating merely from its vicinity to the artery. These diseases might be mistaken for aneurismal varix, but the diagnosis may be formed from the following circumstances: empty the tumour of its blood, and compress the artery above it; if it be aneurismal varix, it cannot again become filled with blood until the pressure be taken from the artery; but if varicose aneurism, it will become immediately refilled: besides, the absence of the whizzing noise is another diagnostic mark.

It was said by Bichat, that the veins were not exposed to ossification, like the arteries; but there is scarcely a museum in Europe, which does not afford a practical refutation to the assertion of this physiologist. In St. Thomas's Hospital is a preparation of the saphena major vein, taken from a subject brought accidentally into the dissecting room, in which the vessel is seen to be completely ossified for a considerable part of its course. It is a well known fact, that the membrane lining the right cavities of the heart, which approximates in structure and function to the internal tunic of the veins, is very rarely found ossified, even in those subjects in whom there would seem to exist a remarkable tendency to the disease; while, on the other hand, the membrane lining the left cavities participates with that of the arterial system generally, in a strong disposition to ossification.

The diseases of the *absorbents* are few; but at advanced

periods of life they invariably become opaque, instead of retaining their natural transparency, and seem therefore to undergo a change approaching at least to disease. By physiologists, however, it is usually considered, that in old age the absorbent system is particularly active, but this is not the case; for notwithstanding the fact, that at this period several parts of the body are removed by the absorbent vessels, it is not to be attributed to their increased action, but rather to the diminished power of the arterial system; so that the equilibrium between the arterial and absorbent system, which exists in the adult period, is lost in old age, from the loss of the power of the arteries; and a wasting of the body therefore ensues.

The absorbents are the subjects of inflammation, and from very slight causes, such as from friction, chafing, or slight wounds, which will produce knotted red lines in the course of the absorbents, along the inner side of the extremities. The knotted enlargements point out the situation of the valves. Incised wounds but rarely produce inflammation of the absorbents; but small punctured wounds in irritable constitutions, are frequently productive of the most alarming symptoms, and sometimes of death. Hence it is, that it is not unfrequent to hear of persons, from merely pricking the finger in working, or with a nail, or fish-bone, dying. In the prosecution of anatomical investigations, it is well known that a wound from the hooks, or a puncture from the end of a rib, or any piece of bone, is much more dangerous than a cut with the dissecting-knife; which has led some to believe, that the ill effects are produced by the absorption of morbid matter. I cannot, however, bring my mind to believe this to be the cause of danger, but would rather attribute it to the peculiar state of the constitution at the time of the injury: which opinion is more or less corroborated by the fact, that if several be wounded from the dissection of the same body, one only is frequently affected. A puncture should therefore be immediately converted into an incised wound, whenever there is any reason to believe the subject of the accident is

irritable; fomentations should be applied, the bowels gently opened, calomel and opium administered at bed-time, and change of air immediately be resorted to. Sir Astley Cooper usually recommended the pupils to apply nitric acid to the puncture: this practice, I must say, I deprecate; as I have frequently seen inflammation of the absorbents immediately take place upon the application of this second irritating cause.

The absorbents are occasionally obstructed by the formation of malignant tumours: in the museum of St. Thomas's Hospital, there is a preparation of a malignant tumour of the size of a walnut, obliterating the thoracic duct; it was taken from the body of a man who died of a fungoid disease of the testicle. Two other instances of obstruction are mentioned by Sir Astley Cooper: one of a tumour formed in the receptaculum chyli, of a scrofulous nature: and in the second case, the valves of the duct were very much thickened.

The absorbent glands are also very subject to inflammation, both from the irritation produced by abraded surfaces, and from wounds, as well as from the absorption of specific poisons. We have instances, frequently, of swelling of the inguinal glands from chafing, as after hard riding; and the formation of buboes from chancre, may be instanced as an example of the second cause.

Ossific depositions not unfrequently take place in the glands, and sometimes in such a quantity, as to convert them very nearly into bone. In the museum of St. Thomas's Hospital, there is a gland, taken from the groin of a woman, which weighed fourteen pounds. The mesenteric glands are also sometimes found to contain portions of bony or earthy matter.

END OF VOL. THIRD.

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PLATE I.

Fig. 1

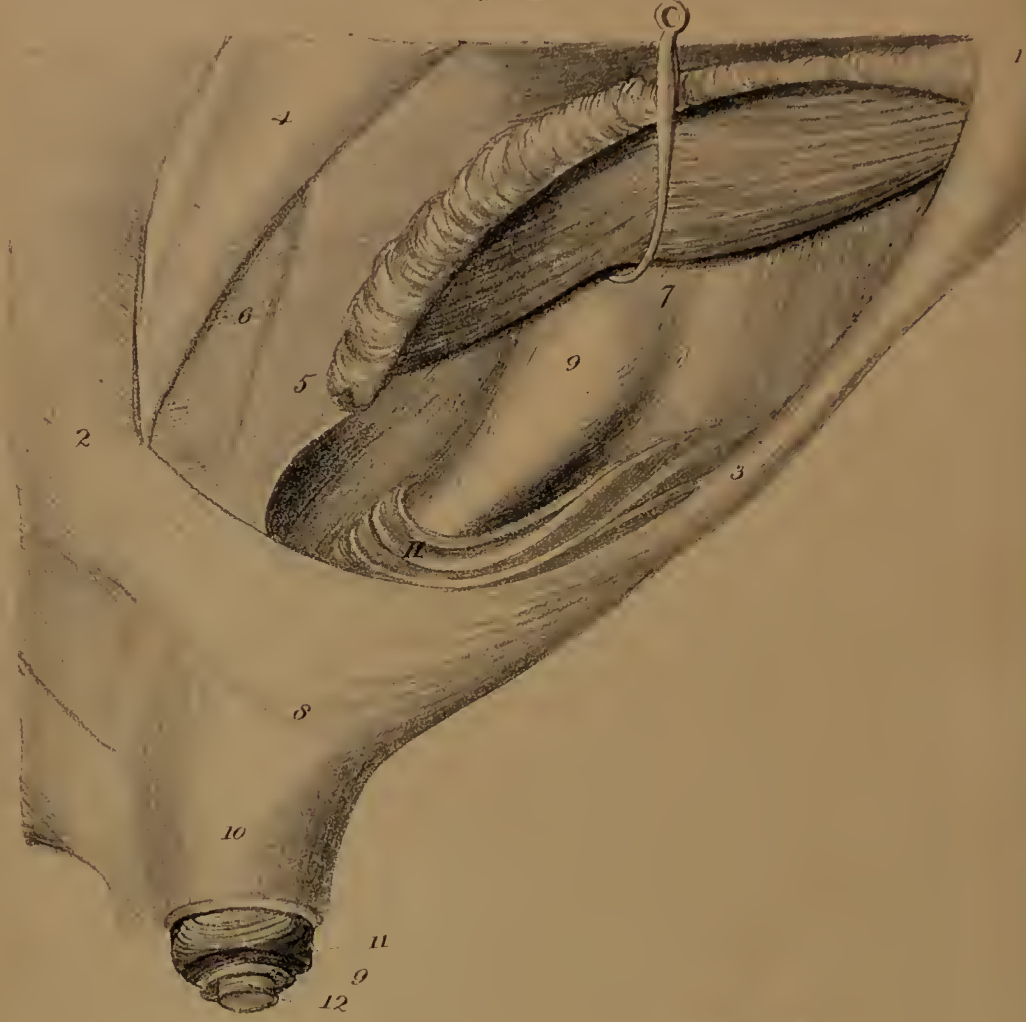

Fig 2

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PLATE I.

Fig. 1.

The fasciæ spermaticæ given off from the rings of the inguinal canal.

1. The anterior superior spinous process of the ilium.
2. The symphisis pubis.
3. Poupart's ligament.
4. The tendon of the external abdominal oblique muscle raised.
5. The united tendons of the internal oblique and transversalis muscle.
6. Sheath of the rectus abdominis.
7. Internal ring.
8. External ring.

9. 9. The fascia spermatica interna.

10. The fascia spermatica externa.

11. 11. The cremaster muscle situated between the fascia spermaticæ.

12. The spermatic cord.

Fig. 2.

A diagram of the parts in Fig. 1.; the references being the same from 7. to 12.

PLATE II.

Fig. 2.

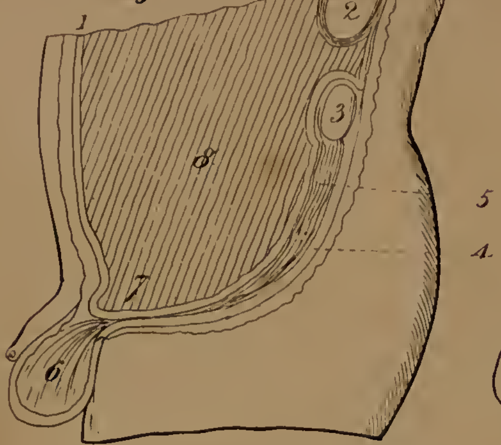

Fig 3

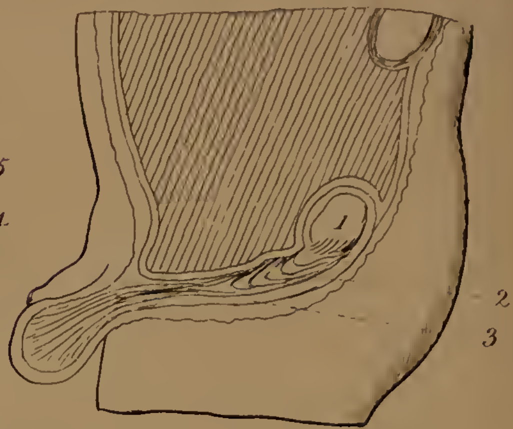

Fig. 1.

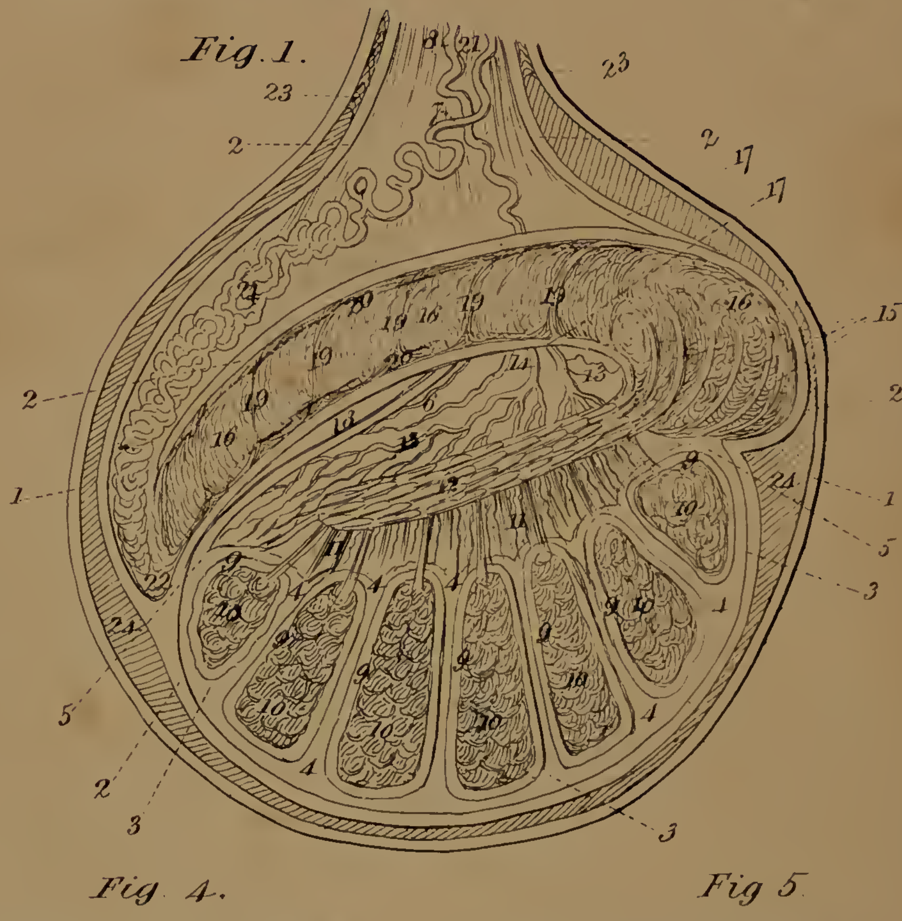

Fig. 4.

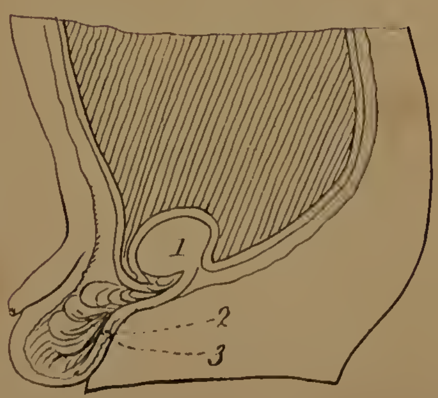

Fig 5.

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PLATE II.

Fig. 1.

A diagram of the structure of the testicle.

1. 1. Tunica vaginalis reflexa.

2. 2. 2. 2. 2. Tunica vaginalis testis.

3. 3. 3. Tunica albuginea.

4. 4. 4. 4. 4. 4. Ligamentous bands given off from the mediastinum, and dividing the glandular structure into lobes.

5. 5. The part where the tunica albuginea splits to enclose the corpus highmorianum, mediastinum, rete, and the entrance of the vessels.

6. The tunica albuginea passing to be lost in the cord.

7. The spermatic cord.

8. The spermatic artery taking a tortuous course to be lost in the tunica vasculosa.

9. 9. 9. 9. 9. 9. 9. 9. 9. The tunica vasculosa, lining the tunica albuginea, and from thence giving off minuter distributions to the lobes, lobules, and tubuli seminiferi.

10. 10. 10. 10. 10. 10. 10. Lobes and lobules of the tubuli seminiferi.

11. 11. The mediastinum enclosing the tubuli, which pass through it to form the rete.

12. The rete passing in a direction corresponding with the long axis of the testis.

13. 13. The corpus highmorianum, above and behind the rete, enclosing the vessels entering the testis from the spermatic cord.

14. The vessels entering from the cord.

15. The vasa efferentia.

16. 16. 16. The epididymis.

17. 17. The tunica vaginalis testis enclosing the epididymis, and uniting the caput and cauda to the testis more closely than its body.

18. The part less closely united than the cauda and caput.

19. 19. 19. 19. 19. Ligamentous bands crossing the epididymis from the back to the fore part, and dividing it into lobes.

20. 20. Ligamentous bands passing along the convex and concave edges of the epididymis in the direction of its long axis.

21. 21. The vas deferens.

22. Sudden duplicature of seminal tube at the junction of the vas deferens and cauda epididymis.

23. Union by adhesion which takes place between the close and reflected portions of the tunica vaginalis.

24. Serous cavity of the tunica vaginalis.

Fig. 2.

A diagram of the testis in the abdomen, previous to its descent into the scrotum.

1. 1. Double line denoting the reflection of the peritoneum.
2. The kidney.
3. The testis behind the peritoneum.
4. The gubernaculum.
5. The cremaster.
6. The termination of the cremaster in the scrotum.
7. The pouch formed in the peritoneum which receives the testis.
8. Cavity of the peritoneum.

Fig. 3.

Second diagram of the descent of the testis.

1. Testis descended to the brim of the pelvis.
2. Cremaster drawn down in folds.
3. Gubernaculum shortened and absorbed.

Fig. 4.

Third diagram of the descent of the testis.

1. The testis drawn into the pouch of peritoneum, above the rings, which corresponds to 7. fig. 2.; and which pouch descends with the testis into the scrotum.
2. The gubernaculum shortened.
3. The cremaster, as it descends, drawn into more numerous folds.

Fig. 5.

Diagram of the descended testis.

1. The testis suspended by the spermatic cord and cremaster.
2. The cremaster muscle.
3. Tunica vaginalis testis.
4. Tunica vaginalis reflexa.
5. The communication between the cavity of the peritoneum and tunica vaginalis, which afterwards closes by adhesion.

PLATE III.

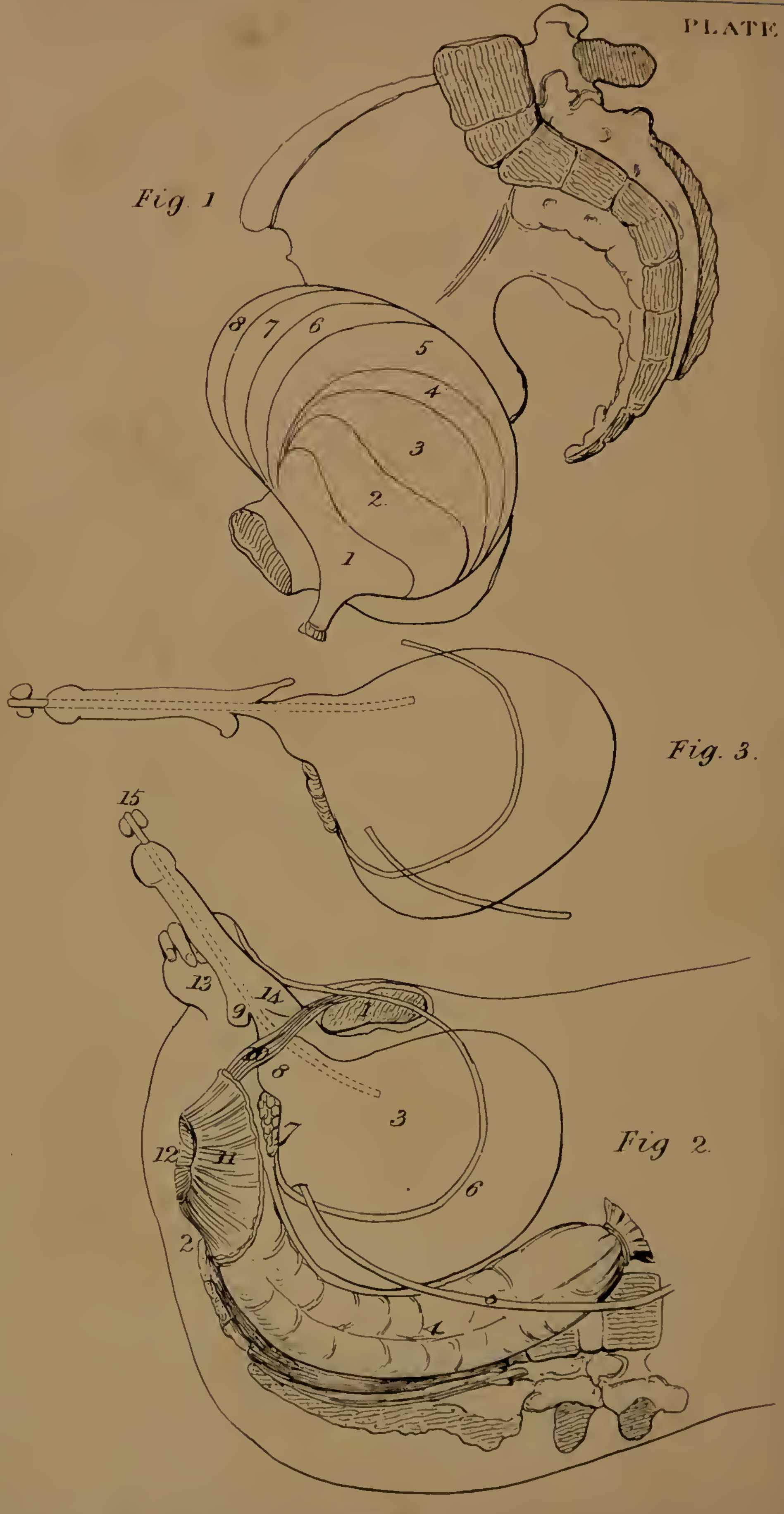

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PLATE III.

Fig. 1.

A diagram of the progressive distention of the bladder—the pelvis in the position of the erect posture of the body.

1. Bladder in an empty state.
2. 3. 4. 5. The progress of ordinary distention.
6. 7. 8. The progress of extreme distention.

Fig. 2.

Diagram of the side-view of the pelvis in the erect posture of the body.

1. Symphisis pubis.
2. Extremity of the os coccygis.
3. Bladder.
4. Rectum.
5. Ureter.
6. Vas deferens.
7. Vesiculæ seminales.
8. Prostate.
9. Bulb.
10. Wilson's Muscle.
11. Portion of levator ani.
12. Anus.
13. Scrotum held aside.
14. Crura.
15. Sound—the course it takes marked by dotted lines.

Fig. 3.

Diagram of the bladder in the same position as in fig. 2., to show the course of the sound, when taken from the assistant by the operator, and the consequent elevation of the prostate from the rectum.

Fig. 1.

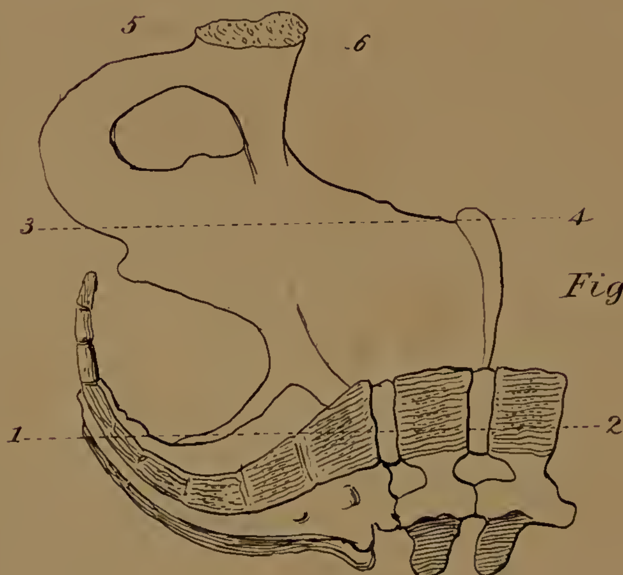

Fig. 2.

Fig 3

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PLATE IV.

Fig. 1.

Diagram of the dimensions of the pelvis in the erect posture.

1. to 2. Perpendicular line of the spinal column.

3. to 4. The antero posterior axis of the pelvis.

1. 3. Acute angle made by the axis of the pelvis with the perpendicular line of the spine, at the upper outlet.

1. 4. Obtuse angle of the axis of the pelvis with the perpendicular of the spine, at the lower outlet of the pelvis.

5. Perpendicular line from the anterior superior spinous process of the ilium to the symphisis pubis.

6. Distance of the lower end of the sacrum to the symphisis pubis, 5 inches and a half.

7. Ditto to the arch of the pubis, 4 inches 6-8ths.

8. Distance from the end of the os coccygis to the symphisis pubis, 5 inches.

9. Ditto to the arch of the pubis, 3 inches 6-8th.

Fig. 2.

Diagram of the position of the pelvis in the operation of lithotomy, side-view.

1. to 2. An horizontal line corresponding to 1. 2. in fig. 1.

3. to 4. The axis of the pelvis now brought nearly parallel with the horizontal line of the spine, which must vary in proportion to the degree of mobility between the vertebræ of each individual.

5. to 6. Axis of the symphisis pubis, parallel with the axis of the pelvis.

Fig. 3.

Diagram of the lower outlet of the pelvis, front view.

1. to 2. A line drawn from one tuberosity of the ischium to the other.

3. A perpendicular line from the arch of the pubis to the middle of the line 1. 2., which marks the precise situation of the raphe of the perineum.

PLATE V.

Fig. 1.

Fig. 2.

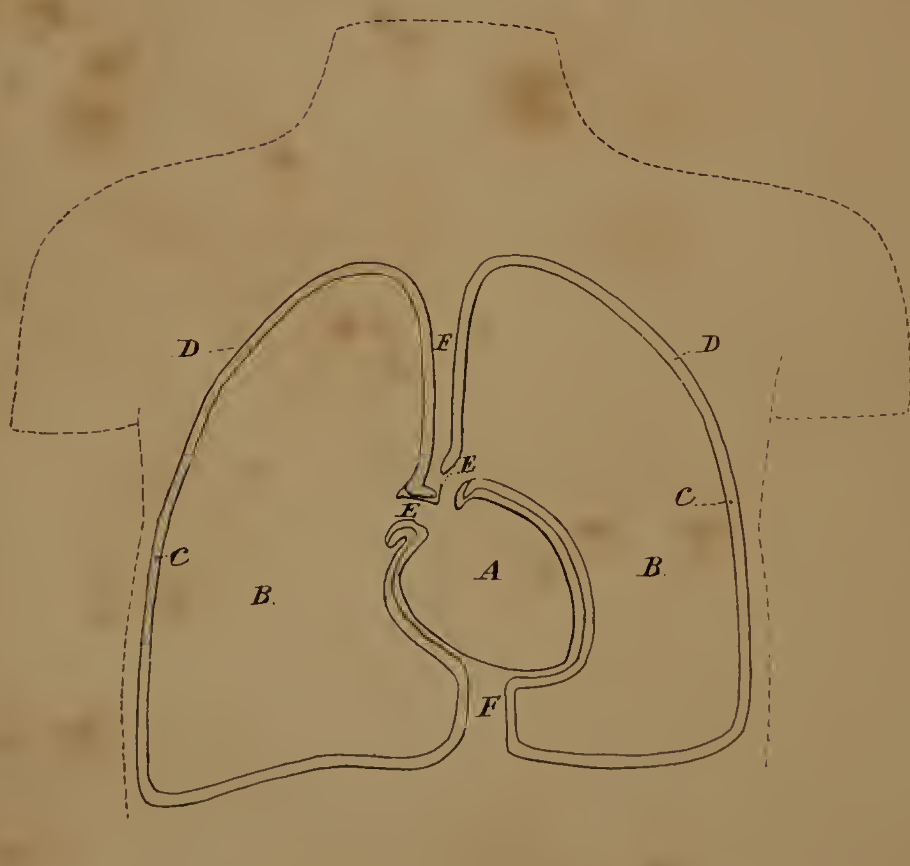

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PLATE V.

Fig. 1.

Diagram of the urethra, to show its contractions and dilatations.

1. The bladder.
2. The bulb of the urethra.
3. The crus penis.
4. The glans.
5. The prostatic enlargement of the urethra.
6. Enlargement in the bulb, termed the sinus Morgagni.
7. Enlargement in the glans, called the fossa navicularis.
8. Contraction in the membranous portion.
9. Contraction at the commencement of the glans.
10. Contraction at the termination of the glans.

Fig. 2.

Diagram of the reflections of the pleuræ.

A. The Heart, covered by pericardium.
B. B. The Lungs.
C. C. Pleuræ pulmonales.
D. D. Pleuræ costales.
E. E. Roots of the lungs, or entrance of the vessels.
F. F. Mediastina.